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HARRISON, THE DRIVER OF CAR 13, DERISIVELY WAVED HIS HAND AT STRANG WHO HAD TO STOP TO MAKE REPAIRS.

HARRISON, WHO HAD TAUNTED STRANG IN PASSING, WAS LATER STALLED BY AN ACCIDENT.

AN ACCIDENT AT EU. MARTIN AND KAPPERSCHMIDT THROWN OUT BY THE BREAKAGE OF A WHEEL. A SECOND ACCIDENT OCCURRED DURING THE GRAND PRIX AT EXACTLY THE SAME PLACE ON THE FOLLOWING DAY.

THE FINISH OF THE VOITURETTE RACE. GUYOT, THE WINNER, RECEIVING THE CONGRATULATIONS OF DELAGE, THE BUILDER OF HIS CAR.

THE WRECK OF CISSAC'S CAR. THE ACCIDENT COST THE LIVES OF CISSAC AND HIS MECHANIC SCHAUBE. THE BURSTING OF A TIRE AND THE INABILITY OF CISSAC TO STOP THE RESULTING ZIGZAGGING OF THE CAR CAUSED A COLLISION WITH A TREE.

From L'Illustration.

THE THIRD GRAND PRIX AUTOMOBILE RACE.

THE THIRD GRAND PRIX AUTOMOBILE RACE.

DESCRIPTION OF THIS LEADING EVENT AND OF THE VOITURETTE RACE PRECEDING IT.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

This year's Grand Prix race was a most successful event in many ways, especially as concerns the public interest. It was held as usual under the direction of the Automobile Club of France, in the northern part of the country, on a circular route about 48 miles long. The grand stand was filled to overflowing with people from all parts of Europe, and there were no less than 300,000 persons assembled around the starting point or nearby. The receipts from the race amounted to $22,000, and there were some 1,700 automobiles present.

The annual speed race has seen some transformations since it was first started. The Gordon Bennett Cup, which was disputed by three cars from each nation, was run in 1903 in Ireland, in 1904 in Germany, in the Taunus region, and in 1905 in France, in the Auvergne district. This was the last of the Gordon Bennett Cup races, seeing that owing to the inequality in the competition the French Automobile Club decided to withdraw from such a contest and to organize an annual race which would replace it and be open to all runners, without regard to nationality, but limiting each constructor to three cars. In 1906 the first of the Grand Prix races was run on the Sarthe circuit in the central part of France, over a distance of 1,200 kilometers (746 miles). Then, in the following year, the distance was reduced to 770 kilometers (478 miles) over the Dieppe circuit lying near the Channel coast. This year it was decided to use the same circuit for the race, covering ten rounds of this circuit, each round figuring 76.988 kilometers (47.82 miles). This gives a total of 769.880 kilometers (478.2 miles) for the entire course.

A novel feature of this year's race lies in the rules which were adopted by the Automobile Club. In all the previous races it was the weight of the car which was taken as a starting point, and in order to keep this weight below the prescribed limits, the constructors were obliged to use light and resistant metals and at the same time to simplify the different parts of the mechanism as much as possible. After several years' work in this direction, the cars were brought to a point where it seemed as if little further progress could be made. But there were still opportunities of improving the motors, and in an effort to do this, last year the rules were changed so as to make the consumption of gasoline play the leading part, regardless of the weight of the car or the power of the motor. But this year it was thought better to deal with the cylinders of the motor and accordingly the rules were changed again so that the cars, to be eligible, had to have a four-cylinder motor with a 155-millimeter (6.2 inches) bore or a motor of equivalent piston area. For a six-cylinder motor, the bore was accordingly 127 millimeters (5 inches). The cars in running order, but not including water, gasoline, tools, pieces, or extra tires, were obliged to weigh at least 1,100 kilogrammes (2,425 pounds). Almost all the cars in the race used a four-cylinder motor 155 millimeters bore, but there was considerable variation in the piston stroke. Some of the motors had a 120-millimeter (4.7 inches) stroke, but the majority of the constructors used a stroke lying near 170 millimeters (6.7 inches), which means a motor capable of developing from 120 to 127 horsepower. The highest stroke was 185 millimeters, which corresponds to a motor of 133 horse-power.

There were forty-nine starters in this year's race, which was held on the 7th of July, with good weather prevailing, although there was a high wind, which was a disadvantage. Seven different nations were represented, and the cars were painted with the corresponding colors: Germany, white; England, green; France, blue; America, white and red; Belgium, yellow; Switzerland, red and yellow; Italy, red. The greater part of the entries were French cars, these numbering fifty-seven and including the racers of such well-known makes as the Renault, Brasier, Mors, Panhard, Clement, etc. Italy was represented by the Fiat and the Itala cars, there being three of each entered. The favorite German team was the Mercedes, which consisted of three cars. Germany also had three Benz and three Opel cars. England had but three cars of the Austin make, while America was represented by a single Thomas stock car, driven by Lewis Strang. Many of the favorite drivers were in the race this year, such as Jenatzy, Baras, Gabriel, Sziss, Wagner, and Thery of the French teams. There were also the Italian champions, Lancia, Nazzaro, Cagno and Henri Fournier of the Italian, Willy-Poege, Hémery, Opel, Hanriot, etc., of the German.

The race was an exciting one, but it did not turn out as was expected for the favorites. At the end of the tenth round there were but few of the French cars in the race, and the Italians had also dropped behind, owing to numerous accidents. On the other hand, the German teams did well, and their victory was well deserved.

The race was unusual from the fact that the position of the champions changed greatly from round to round. The best time for the first round was made by Salzer, on a Mercedes car, but in the second round the Italian Nazzaro on a Fiat came ahead. Then, in the next two rounds, Wagner (Fiat car) and Hémery (Mercedes car) came to the front. In the fifth round, however, Lautenschlager on a Mercedes car took the lead and kept it until the finish. Thery, who drove a brilliant race, made the best time during the sixth round, but he was then running in only fourth place. He had an accident in the ninth round and was not able to finish. But twenty-three of the cars finished the race. The German Mercedes driven by Lautenschlager was the winner. This car covered the ten rounds of the circuit in 6 hours, 55 minutes, and 43 4/5 seconds. This, however, did not equal Nazzaro's performance on the Italian Fiat car over the same circuit last year, since his time then was 6 hours, 46 minutes, and 33 seconds, corresponding to an average speed of 70.5 miles an hour, while the Mercedes car this year averaged but 69 miles an hour. Second place was taken by Hémery, on a Benz car, in 7 hours, 4 minutes, and 24 seconds (average speed 67.6 miles per hour), and the third place by Hanriot, on another Benz, in 7 hours, 5 minutes, and 13 seconds. It will be remembered that the Benz firm figures in the early history of the automobile, it being one of the established makes of Germany, but this is the first time it entered in a big race, and its success has proved the merit of its machine. The first of the French team to finish was Rigal, on a Bayard-Clement racer. This machine secured fourth place in 7.30.36 3/5, while fifth place fell to a Mercedes car, piloted by W. Poege. An Opel car (Erns) took sixth place, followed by a Benz, Renault, Panhard-Levassor, German (Belgian), Itala, and the following French cars: Bayard-Clement, two Motoblocs, Renault and two Mors cars, one of them driven by Jenatzy. Strang, with his American Thomas car, was obliged to drop out at the fourth round. He stripped his first and second speed gears just before the race, but managed to run four rounds, only to finally be obliged to drop out owing to a leaky gasoline tank.

What was especially noticeable in this year's race was the great wear upon the tires. Most of the leading champions were thrown out of the race on this account. The roads were in a bad condition, owing to the fact that they had been cut up considerably by the cars running over the circuit in order to try it before the race, and also by the many tourist cars. This caused the tires to be worn down in a short time, and some of the drivers had to replace their tires as many as twenty times in the race. Removable rims were used this year considerably, but a burst tire often results in the metal rim being thrown off the wheel, with the result that the wheel is liable to break and cause a bad accident, or at least put the car out of the race.

Thery, Nazzaro, Lancia and other favorite drivers were unable to finish for this reason, which caused the French and Italian teams to make a very poor showing. The German team had much better luck with their tires, for what reason it is difficult to say, since their cars, too, were fitted with detachable rims. Burst tires and broken wheels may be said to be the feature of this year's race, and this is not all, for a fatal accident occurred from this cause, which cost the life of Cissac and his mechanic, Schaube, who were driving a Panhard-Levassor car. Cissac, it seems, was going at full speed on a down stretch of road, when a tire burst, causing the car to take a zigzag path, and in spite of Cissac's efforts to brake it, to run against a tree, breaking the latter off, after which it overturned, throwing out both men violently, and killing them instantly. The left rear tire, which had burst, was torn off, together with its rim, and the other rear wheel was smashed to pieces. Cissac was well known as a motor-cycle champion, and this is the first time that he entered a heavy car event. In the eighth round, toward the last of the race, he was among the first, and held fifth place.

The cup offered by the city of Dieppe for regularity was won by the Benz firm, whose three cars were able to finish and, at the same time, to make a remarkable performance in this respect. On the day before, there was held a voiturette race in which there were sixty-three entries. This event was won by a Delage car, and the entire team of this make, consisting of three cars, succeeded in finishing, and in winning the cup for regularity which the Petit Journal of Paris awarded. The winner averaged 50 miles an hour. Eight complete teams managed to finish the race.

ALCOHOL VERSUS GASOLINE.

In reply to inquiries from the United States, Consul-General Robert P. Skinner, of Marseille, furnishes the following information relative to the status of alcohol and gasoline as power producers in France and the efforts which have been made toward the general use of the former:

Real and rapid progress has been made in overcoming past objections to the use of alcohol, and when the price of denatured alcohol is somewhat lower than the price of gasoline, it can be substituted for the latter, both for automobiling and general power purposes. Former reports showed that the high cost of alcohol, excessive consumption, and the resulting oxidation of mechanical parts had not been counterbalanced by any discoverable advantages. How seriously these problems have been attacked may be judged from the expression of an informant—perhaps the most important French manufacturer of carburetors—who writes under date of March 28, 1908:

"We consider the problem of the industrial use of the alcohol motor solved. The carburetors invented in view of this utilization have given satisfactory results. The use of alcohol will become more advantageous when an understanding is brought about between the producers, whereby prices shall be fixed, and when the State shall have solved the problem of the denaturing agent."

If ingenuity has mastered the material difficulties in the way of substituting alcohol for gasoline, commercially the problem is almost as insolvable as ever; and if it is insolvable in France, where gasoline is dear and alcohol relatively cheap, it must be still more so in the United States, where gasoline is cheap and alcohol dear. Nevertheless, with raw material available for the manufacture of alcohol in every country under the sun, and with very few gasoline producing centers, it is hardly venturing too much to assume that ere many years there will be a permanent and general use of alcohol as a source of motive power.

The one serious and sustained practical experience with alcohol as a motive power in France is that of the Compagnie Générale des Omnibus de Paris, the heavy public vehicles of which traveled 2,218,291 miles between June 11, 1906, and November 1, 1907, propelled by a mixture of 50 per cent of carbureted alcohol and 50 per cent of benzol. Benzol, it may be added is of recent manufacture in France, where it is obtained by the condensation of gases recovered from coke. The company named is more than satisfied with its venture and proposes to continue the use of this mixture.

This experiment is conclusive in its material aspects, but it is successful commercially only because of the artificially high price of gasoline in the city of Paris, brought about by the imposition of an octroi tax of 20 francs per hectoliter ($3.86 per 26.42 gallons). The effect of this municipal taxation is such that in Paris gasoline was worth in November last 56 francs per hectoliter ($10.81 per 26.42 gallons) against 39 francs $7.53) for carbureted alcohol, the octroi duty upon which is only 5.10 francs (98 cents) per hectoliter. These octroi taxes vary greatly in different municipalities, and leaving them out of consideration, the general price of gasoline in France last November was 36 francs ($6.95) per hectoliter and that of carbureted alcohol 33.90 francs ($6.54). Though the advantage as to price is apparently with carbureted alcohol, it must always be remembered that the consumption of this fuel exceeds that of gasoline by about 5 per cent.

Thus, for the moment, while alcohol motors can be used and are used, no real economy has yet been effected by the use of alcohol as a fuel, granting its equal efficiency, and there is the further disadvantage that no commercial organization exists whereby automobile owners are assured of obtaining supplies throughout the country.

The Italian state railways have decided to adopt liquid fuel on some of the mountain lines with long tunnels. The special reduction of duty on mineral oils now accorded to Italian state railways will make the cost of working by liquid fuel not prohibitive; and this cost will be still further reduced when it is found convenient to import it by means of special tank steamers. During the fiscal year 1906-7 the cost of coal on Italian railways amounted to 17 cents per train mile, against France's 10 cents.

CALCULATIONS FOR CHOKING COILS.

SOME SIMPLE FORMULÆ.

It frequently happens in practice that some form of electrical apparatus has to be connected to the supply mains having a higher voltage than that for which the apparatus is designed, and in such cases it becomes necessary to reduce the voltage so that the current flowing through the apparatus does not reach an abnormal value. As an example, an arc lamp requiring only 50 volts may have to be supplied with current from mains working at 100 volts or over. The best way out of the difficulty is to connect two or more lamps in series; but this is not always possible, and even if it is possible it may not be desirable. In the case of a direct-current supply, the problem of reducing the voltage at the lamp terminals is very easily solved, for it simply remains to design an ohmic resistance which, when the proper current is flowing through it, gives the desired drop. This is extremely simple, but, at the same time, gives rise to considerable waste of power, as can readily be seen, the same number of watts being wasted in the resistance as are being expended on the lamp, and consequently the consumer pays just as much for reducing the pressure as is paid for the light. Unfortunately, with direct current this is unavoidable, but where an alternating current is used this loss can be very much reduced if a choking coil is used in place of the ohmic resistance. The design of a choking coil presents but little difficulty, and involves no great knowledge of alternating current. In the first place, it is necessary to observe that the voltage which must exist across the terminals of the choking coil to reduce the voltage at the lamp terminals is not given by 100—50, as previously shown for an ohmic resistance for use in a direct-current circuit. In the present case the E.M.F. due to the self-induction of the choking coil is very nearly 90 deg. out of phase with the effective E.M.F. The various voltages which we have to deal with may be represented by a right-angled triangle. The base of this triangle represents the voltage across the terminals of the lamp, the perpendicular the volts across the choking coil, and the hypotenuse the voltage across the mains. Hence, if we know the voltage across the mains and the voltage required across the lamp, we can find the value of the choking-coil voltage, for it is the length of the perpendicular of the triangle. Using the same figures as before, we have voltage across choking coil terminals equals

$$\sqrt{100^2 - 50^2} = 87 \text{ volts.}$$

Having found the voltage which the choking coil must give across its terminals, let us examine the formula for giving the voltage of a choking coil. The formula is

$$E = \frac{4.44\, N\, n\, T}{10^8} \qquad (1)$$

where N is the magnetic flux, n the periodicity of the supply, and T the number of turns. It will be seen from this that the only two quantities over which we have control in designing a choking coil are N and T, and that we can vary these in whatever way we like, provided their product remains constant. From the above formula—

$$N\,T = \frac{E \times 10^8}{4.44\, n} \qquad (2)$$

At this stage it may be mentioned that in a choking coil of this type it is not advisable to have a closed magnetic circuit, as would be obtained, for example, by winding the wire on a laminated iron ring. If we do this the reluctance of the magnetic circuit would be very small, and we should have a big N, and a correspondingly large section of iron. It is usual with such choking coils to introduce an air gap in the iron circuit, and in the calculations to neglect the reluctance of the iron part of the circuit, and to assume that the whole of the reluctance is due to this air gap. Plates of 15 mils thickness, and of the shape of a block letter "C," frequently consitute the core for choking coils of this type. In the present example we will fix the length of the air gap at 0.5 centimeter. The volume of iron to be used can best be found by deciding upon what loss is to be allowed in the core. The watts taken by the lamp are 10 × 50 = 500, and if we limit the core losses to 10 per cent of this it will be a very fair value, and it will be noticed, neglecting the loss in the windings, a saving of 40 per cent will result by employing a choking coil instead of the ohmic resistance. The formula for the iron losses in a transformer or choking coil is

$$W = V\,(K\, n\, B^{1.6} \times 10^{-7} + t^2 n^2 B^2 \times 10^{-16})$$

where V is the volume of the iron in cubic centimeters, n the periodicity, K a constant = 0.0024, t the thickness of the iron plates in mils, and B the maximum flux density. As regards the last quantity, this is the virtual flux density multiplied by $\sqrt{2}$, or 1.414. In the same way we shall presently have to deal with the maximum current, which is 1.414 times the virtual current, or the current registered on the ammeter. If we take the virtual flux density as 5,000 per square centimeter, which is a suitable value for choking coils, then the maximum flux density will be 5,000 × 1.414 = 7,000. Assuming the periodicity of the circuit to be 80 cycles per second, we can then fill in the values of the above formula, and calculate the volume of the iron, which will be found to be 1,470 cubic centimeters.

In order to find the number of turns of wire to wind on the core, it will be convenient to assume that we have only to force the magnetic lines through the air gap. If we do this, then we may write

$$\text{Ampere turns } A\,T = L\,B/1.257$$

where L is the length of the air gap in centimeters. Putting the values in this formula, we have $A\ T$ = 2,800.

Dividing this by the maximum current $\sqrt{2} \times 10$, we have

$$2{,}800/14.14 = 200 \text{ turns.}$$

Multiplying this value by the flux in one square centimeter of the iron, we have 200 × 7,000 = 1,400,000; but if we put the values in formula (2) we can calculate what the actual product of the flux and turns should be:

$$\frac{87 \times 10^8}{4.44 \times 80} = 24{,}500{,}000.$$

It will be noticed that 87 is the virtual value of the volts, as registered by the voltmeter. Therefore, to find the area of the core, we must make 1,400,000 a virtual value—that is, divide it by $\sqrt{2}$, when we have area of core

$$\frac{24{,}500{,}000}{\dfrac{1{,}400{,}000}{\sqrt{2}}} = 25 \text{ square centimeters.}$$

The total length of the core will obviously be the volume divided by the area,

$$\text{or, } 1{,}470/25 = 59 \text{ centimeters,}$$

measured from the two faces at the air gap. The core plates should be built up so as to give a square section 5 × 5 centimeters. It now simply remains to select a cotton-covered wire having a carrying capacity of 10 amperes on a basis of 1,000 amperes per square inch, and to wind 200 turns on the limb opposite to the air gap. It may be found that a few more or a few less turns are required to get the correct voltage at the lamp terminals, and it is advisable to test the coil before the wire is cut. The laminations must be insulated from one another by insulating varnish or paint, or, better still, with thin paper fastened to the laminations with shellac varnish.—The Practical Engineer.

LOCOMOTIVE STANDARDS.

It would be a long step toward the millennium if all parts of a locomotive could be standardized, and the subject will probably continue to be a puzzling and interesting one for some time to come. There is, of course, such a thing as standardization run riot, where futile attempts are made to do the impossible, but ordinarily such a state of affairs is checked by the necessity for economy. It was shown at a topical discussion on the subject at the Master Mechanics' convention that the exercise of "horse sense," and careful study in the drawing room are needed in order to make a success of standardization. It was also apparent that local conditions were a governing factor, with the result that while certain parts could be readily standardized as between some classes and sizes of locomotives, it would be impossible with others.

The object of such work is to decrease the amount of stock carried for repairs, and to lower the cost of making such parts by the possibility of manufacturing in quantities. While, at first sight, it may seem impossible to standardize locomotive parts to any very great extent, because of the difference in types and sizes in use, especially where a part strong enough for locomotives with large cylinders is too heavy for those with small cylinders, there are, nevertheless, many details to which this does not apply, such as pilots, headlights, whistles, sand boxes, etc., which are entirely independent of the size and type of the engine.

Aside from these matters of detail it was also urged at the convention that it might be profitable to have fewer classes of locomotives. Instead of many types, suitable for different classes of service, it might be good policy to have but one or two types, and accept the criticism of running a heavy locomotive on a short train, as offset by the benefit of having locomotives that will handle any trains they may be put on.

In speaking of what could be done along these lines, Mr. Vaughan, of the Canadian Pacific, said that his road had been particularly fortunate in such work. In getting up a new line of engines the first was a consolidation, for which 21-inch by 28-inch cylinders and 57-inch wheels were adopted. After the consolidation came a 10-wheel with the same cylinders, and after that two Pacific type engines with same size of driving wheels; next came a hump switcher, and then some 10-wheels with fireboxes for anthracite coal as well as using the normal firebox for bituminous coal. These engines are working from Vancouver down to St. John, N. B., the whole way across the continent, and serve to illustrate that it is possible to get one type of engine that will work under fairly dissimilar conditions.

There are only two sizes of engines on the Canadian Pacific; one has a saddle 3 inches wider than the other; the rod brasses, driving boxes, throttles, rockers and other details are used right through the whole series. The result is a class of power such that no matter how the transportation department distributes it, there is no worry about sending castings from one division to another to fit the engines that happen to be put on that division. In this way there is a line of parts that go on virtually every engine.

Commenting on this method, it was urged that it would always be well to take time and study the matter carefully before establishing a standard definitely, and that time spent in the drawing room in considering these matters is time well spent. Thus one reason assigned for the successful operation of this method on the Canadian Pacific is that a year is taken to design a new engine, and hence it is possible to proceed with great care in the establishment of new standards.

This working up of standards for new locomotives met with approval, but it was considered inadvisable to attempt to standardize old locomotives, with the exception of a few fixtures and attachments. Nor would it be worth while to throw away a part that is perfectly good and serviceable merely for the sake of substituting a standard, as that would be defeating the very object of the application, namely, to save expense and waste. But when the whole matter is sifted to its final essence it becomes a question of meeting local conditions in individual cases, and no clearly defined limits can be set as to what may not be economical or good practice in the establishment of locomotive standards.—Railway Age Gazette.

A NEW SALT-REFINING PROCESS.

The British salt-manufacturing industry is deeply interested in a new refining process that has been evolved, and one which promises to completely revolutionize the trade. By its utilization the involved and expensive evaporation process is completely superseded. The crude salt combined with its impurities is dumped into an open-hearth furnace, where it rapidly becomes converted into a molten condition. The furnace is then tapped, and the molten mineral is drawn off into a huge iron mold or converter. A stream of compressed air is then projected through the mass, which precipitates the impurities, owing to the agitation of the mass, to the bottom of the converter. This operation occupies about an hour, and then the salt is permitted to cool and recrystallize. The converter is then discharged, and the mass is secured with the impurities lying caked at the bottom, while the salt itself is snow white and pure, ready for grinding and shipment. In a recent test some 4,000 pounds of the crude article were charged into the furnace, of which eighty per cent ultimately yielded pure salt, the balance being various impurities associated with the raw mineral. During the smelting operation the temperature of the furnace is raised to between 1600 and 1800 deg. F. The cost of production is very low, averaging $1.25 per ton. In this particular experiment the fuel used was slack coal, a ton of which is sufficient to produce 15 tons of pure salt. One advantage of salt obtained by this process is the destruction of its absorbent quality, the salt crystals being very fine and absolutely free from moisture, so that it does not cake by coming into contact with and so readily absorbing atmospheric moisture as does the article produced by the ordinary evaporative methods.

To Preserve Articles of Wood.—*a.* 1,000 parts of brown shellac, 125 parts of Venice turpentine, 127 parts of rosin melted in a roomy kettle. After a time add 6,000 parts of 90 per cent alcohol; use as a varnish. *b.* Dilute water-glass with about 25 per cent of water and paint the vessels with it quite hot; after a second coat and time to dry give a coat of about 1 part of bicarbonate of soda in 8 parts of water.

THE CONSTRUCTION OF MACADAM ROADS.*

HOW RURAL HIGHWAYS MAY BE IMPROVED.

BY AUSTIN B. FLETCHER.

This article is intended as a brief description and discussion of the several processes and essential features entering into the construction of macadam roads in rural sections. The details of construction may require modification to some extent to be suitable for different parts of the country, depending upon amount of rainfall, temperature, and topography, but the general type of road to which this article relates is adaptable to nearly all parts of the United States where suitable stone exists or to which such stone may be carried without excessive cost.

The word "macadam," as herein used, means a surfacing composed of broken stones of small dimensions, the largest not exceeding 2½ inches in diameter, suitably bound together into a compact mass so as to be substantially a sort of concrete, but with no matrix other than stone dust or screenings. A road so surfaced might be more properly called a "broken-stone" road.

The macadam type of road surfacing is particularly well adapted to main ways connecting centers of population, on which there is a moderate volume of travel. It is not an economical form of pavement for the main streets of cities and large towns, and it is usually too expensive for country roads other than the main ways. It resembles closely the gravel road. When the road built of gravel is not quite sufficient to resist successfully the wear and tear of the traffic over it, macadam surfacing may usually be substituted for the gravel with satisfactory results. Sometimes the macadam surface may be used with economy when the conditions are such that a gravel surface would satisfy the demands of traffic, but good gravel cannot be obtained at a reasonable cost.

The increasing use of motor vehicles is causing in many places an insistence for harder, smoother road surfaces, and many miles of macadam road are being constructed at the instance of the motorists. It may be that some type of road will be discovered in the future which will serve the motor vehicles as well as macadam and at a less cost.

For ordinary country roads, experience has shown that the broken-stone way need not be more than from 12 to 15 feet wide, if suitable shoulders are built on each side. Twelve feet allows two vehicles to pass each other safely. Fifteen feet allows a little more space for comfort, particularly when motor vehicles are passing each other, and, including the shoulders, this width will permit a team to stand beside the road while two vehicles are passing. If the stone is less than 12 feet wide there is a likelihood that the edges of the macadam will be sheared off by the wheels unless the shoulders are made of especially good material. Whatever may be the width of the stone, the shoulders should be firm enough to permit the occasional passage of wheels over them.

Until within comparatively recent years it has been almost universally the practice to build thick macadam roads. Roads less than 8 inches thick were rarely heard of, and often a thickness of at least 12 inches of macadam was thought to be necessary for good work.

The modern practice is to make the macadam surface as thin as possible, yet with sufficient body to stay in place, the theory being that the macadam is only a wearing surface. By lessening the thickness of the macadam much expense may be saved, since the foundation materials are usually less costly than broken stone. The macadam should be hard, smooth, and impervious to water. Much attention must be given to the foundation. It should be composed of porous material free from clay or loam, firm, and sufficiently strong to sustain any load likely to come upon the road at any time of the year.

In new work, where no macadam has been laid before, 3 inches of macadam after rolling is the least thickness which is practicable, and, except in unusual cases, a depth greater than 6 inches after rolling is rarely necessary if the foundation is suitable.

The ordinary macadam road is usually from 12 to 16 feet wide, with shoulders in addition 3 to 5 feet in width on each side of the broken stone. The thickness of the macadam is usually 6 inches at the center and 4 inches at the sides, or a uniform depth of 6 inches throughout. While the width and depth of the stone are often less than the dimensions given above, only in exceptional cases are they increased.

The principal qualities which are necessary in road-building stones are hardness and toughness. The cementation values of the stone dust should not be forgotten, but these are not so important as the qualities first mentioned. Often the choice of stone is very limited.

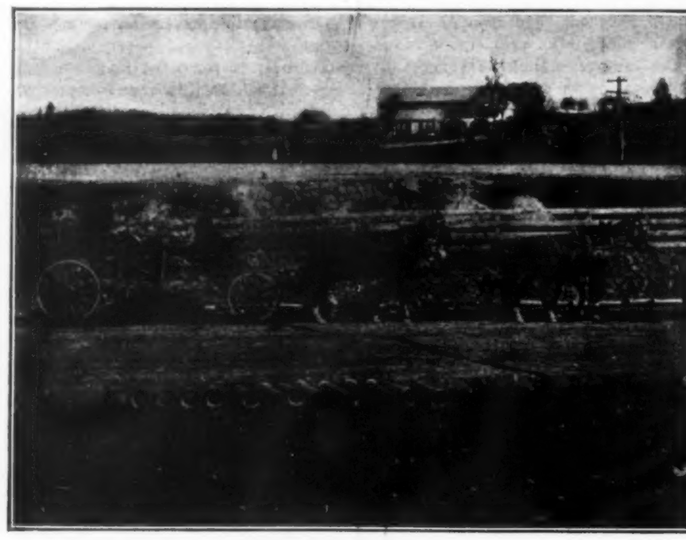


Fig. 2.—SHAPING THE SUBGRADE.

Trap rock, meaning by the term the diabases, the diorites, and certain other igneous rocks, has been long considered the best material for macadam purposes. Unfortunately, except in certain localities, these stones are not common. Some of the hornblendic granites give good results, as do the felsites and some of the harder limestones.

The slates, schists, most of the sandstones, the micaceous granites, and the quartzites have but little value as road surfacing material. Often these stones may be used economically in the lower course of the macadam, provided the upper stratum is composed of a better grade of stone. But road officials should avoid the selection or rejection of stones because of their names alone. Some large-crystaled granites and some of the limestones are of very little value, and, on the other hand, there have been instances where certain schistose rocks have been used with excellent results. Stone from a ledge, because of its uniformity in desirable qualities, is usually better than field stone and makes a smoother and more durable road, but if the ledge is of an inferior grade of rock, it should not be used, merely because it is ledge, in preference to field stones of a better quality of rock.

At the present time there should be no difficulty in determining the relative values of stones for road purposes in any locality. The Office of Public Roads, of the United States Department of Agriculture, now undertakes to make tests and analyses of samples of stones, without charge, and to give advice as to their value for road-building purposes.

When broken stone is bought from a manufacturing company it is frequently sold by weight. Before estimating the cost of a road for which the stone is to be paid for by weight, the road official must know how much the stone will weigh per cubic yard. The somewhat general impression that all stone weighs the same per unit of volume and that a cubic yard of broken stone always weighs a ton and one-third is erroneous.

Data recently published by the Office of Public Roads show wide differences in the weight of different rock. Thus a cubic yard of peridotite (trap) weighed 1.43 tons to the cubic yard, while a sample of granite weighed only 1.11 tons. Differences as marked as these are found in other stones. It should be stated that after broken stones have been carried for some distance on the cars or in carts they pack and a given weight will not occupy so much space as before it began its journey. In contracting for stone by the cubic yard the place of measurement should always be agreed upon in advance.

In addition to the shovels, picks, and other ordinary implements of construction, a considerable outlay for machinery is necessary. In these days of high-paid labor and short working hours one rarely hears in this country of macadam stone being broken by hand. It is true that in some of the State prisons labor may be used for this purpose, but even then the economy of the practice is doubtful.

There are many kinds of stone crushers on the market. Except for city use and in cases where a large amount of macadam work is done every year within a comparatively small area, large stationary plants are undesirable. There are several kinds of portable plants which may be bought at prices ranging from $1,600 to $2,500, which are admirably adapted for country use. These plants include the stone crusher engine and boiler, portable bins, revolving screen, and an elevator to lift the stone after it is broken and to

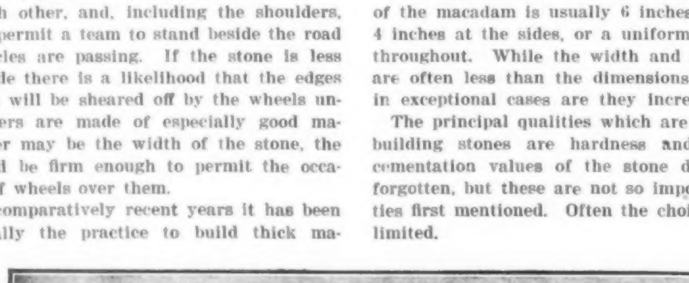


Fig. 1.—PORTABLE CRUSHING PLANT.

* Abstracted from a Bulletin published by the United States Department of Agriculture.

discharge the stone into the screen. (See Fig. 1.)

The outfits are mounted on wheels and may be moved from place to place at a comparatively small cost. Under ordinary conditions from $50 to $100 will pay the expense of shifting such a plant from its old location to a new location several miles distant.

Stone crushers are variable in their outputs. They all need much repair work from time to time, on account of the severe usage to which they are subjected. With an outfit such as has been mentioned, from 80 to 100 tons (60 to 80 cubic yards) of broken stone per day may be reasonably expected if the plant is kept in good condition. Such an output is usually satisfactory, since a single steam road roller will not often roll more than this amount in a day.

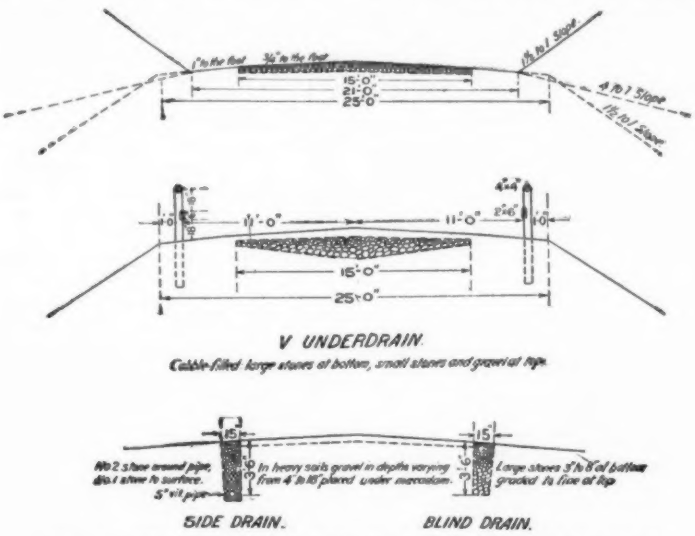


FIG. 3.—TYPICAL CROSS SECTIONS OF MACADAM ROADS.

The crusher will take stones which measure up to approximately 7 by 14 inches in cross section; larger stones require mauling before they can be placed in the receiving orifice.

In some places it may be found more economical to have the stone shipped in from some permanent crushing plant than to purchase a crushing outfit, and it is well to consider this feature carefully. It should also be stated that while the first cost of the road is important, the costs of future maintenance must also be taken into account. It is sometimes economical, even at a greater initial cost, to import stone from a distance, if thereby a more durable road may be had than is possible by the use of local stone.

In places where the stone supply is limited to ledges at infrequent intervals, there is often but little choice as to the location of the crushing plant. It is as easy to haul the broken stone to the road if the crusher is set up at the ledge as it is to haul the unbroken stone from the ledge to the crusher if set up beside the road. But if field stones are to be used or suitable ledges are available along the road to be constructed the crusher should be located near the road. In the latter case, experience has shown that two miles of road is about the economical limit for the operation of a single plant. If a greater length of road is to be built it is usually cheaper to move the plant than to haul its product a longer distance.

The plant should be set up as nearly in the center of the length to be built as is practicable, but since much water is needed for the boiler, for the roller, and for the watering cart, the crusher site is often governed by the location of the water supply.

If possible the crusher should be set low enough so that a platform may be built at the level of its receiving orifice. This platform should be sufficiently strong to bear the weight of the carts loaded with stone for the crusher. With this arrangement the large stones may be dumped upon the platform and fed into the crusher without lifting them.

The workmen who set up the plant should have had experience in this work. Much depends on the proper alignment of the several parts, and many petty annoyances in operation will be avoided if the work is done properly in the first instance.

The steam roller is now used to so great an extent that a discussion of the advantages of rolling with a horse roller, as compared with the merits of rolling with a steam roller, is unnecessary. It is enough to say that experience has demonstrated that quicker and better work can be done with the steam roller and usually at a less cost. A so-called "10-ton roller" is sufficiently heavy for country roads. Most of the culverts and many of the bridges are too weak to sustain, with safety, the heavier rollers. There are several excellent makes of such rollers, which may be had at prices ranging from $2,500 to $3,500.

Since water is always needed in rolling the macadam, a watering cart or sprinkler should be provided. A cart with a capacity of from 450 to 600 gallons will be sufficient. Most of these carts are provided with extremely broad tires, so that the cart assists in consolidating the stone, instead of rutting it.

Most road officials have a road machine which they can use. This is a most serviceable implement when used properly. Often it is misused in repairing earth roads. The practice of scraping back upon the road worn-out material which has been washed into the gutters cannot be too heartily condemned. It is difficult to refrain from enlarging upon this point. The scraper can be used to advantage in preparing the road for the broken stone. Drag scrapers are also useful in grading and shaping the road preparatory to spreading the stone.

Self-spreading carts of several different kinds are often used in spreading the broken stone. They are useful and save considerable time and labor, but are not essential.


FIG. 4.—SIDE DRAIN UNDER CONSTRUCTION.


FIG. 5.—CONCRETE CULVERT END.

In macadam work, as in all other construction work, there should be a competent foreman or superintendent in charge.

Since no two pieces of road are ever alike, no definite statement can be made as to the number of men required for the grading and other details, except with regard to the broken-stone portion of the work, and the same is true with regard to teams. The foreman has an opportunity to use considerable judgment and skill in arranging his men and teams so as to secure a maximum of effect with a minimum of effort.

Not many laborers are required to take care of the output of a single crushing plant. The crusher engineer and the roller operator should be skilled mechanics. Both of these men act as firemen, and usually take entire care of the machinery under their charge. Two ordinary laborers are usually enough to feed the crusher, with a third man to assist them occasionally and to maul stones which are too large for the receiving orifice. Two spreaders are needed to take care of the broken stone as it is delivered on the road, and a driver and a pair of horses are required for the watering cart. It is impossible to give the number of teams needed for the broken stone, since the number is dependent almost wholly on the length of haul.

To show how the number may be ascertained in a specific case, the following example is given: Assuming that the average length of haul from the crusher to the point of delivery on the road under construction is 1 mile; that the route of haul offers no unusual difficulty in grade or surface; that 100 tons (about 80 cubic yards) of broken stone per day is to be hauled to the road; and that 2 tons are to be carried in each 2-horse load; then one team to do the work would have to make 50 trips of 2 miles each, or, in other words, it would have to travel 100 miles per day. Since a pair of horses will not average more than 20 miles a day for many consecutive days, under the conditions assumed, five teams would be necessary.

If the crusher is set up at a ledge there will be no teaming to it, but if field stones are to be crushed, the hauling of these stones to the crusher must be considered also, unless, as frequently happens, farmers haul the stones from their own land and deliver them at the crusher at prices agreed upon.

The ordinary road official rarely has to build a new road. If such a task is imposed upon him he usually requires the assistance of a civil engineer to lay out the work, to establish the grades, and to set the grade stakes. Often in rebuilding an existing way it is advisable to change the grades to a considerable extent, and then the services of a civil engineer are likewise required.

It is obvious that the subgrade or foundation is the part of the road most nearly permanent. No matter what surfacing material is used, it will eventually wear out and require renewal. The grades, therefore, should be most carefully studied, since after the macadam surface is completed they cannot be changed without great expense.

In American practice the maximum grade for important roads has been generally fixed at 5 per cent where such a grade can be had without too great cost for grading and for payment for damage to abutting property. By 5 per cent is meant a vertical rise of 5 feet in 100 feet of horizontal distance. A horse can trot without especial difficulty up such a grade. On steeper grades, macadam surfaces, or, indeed, any kind of a surface, can be maintained only at considerable cost.

Theoretically, the grades should be as nearly level as possible. Practically, in road construction little is ordinarily done beyond reducing the hills to the maximum grade which has been adopted and in removing the irregularities between the hills. If suitable, the materials excavated from the hills are used in filling the depressions.

Some authorities insist that a macadam road should never be level, arguing that a slight rise and fall is needed to permit the surface water to run longitudinal-

ly along the road. Usually, even if the road is absolutely level, if it is also properly crowned, the gutters of the road may be so graded as to provide suitably for surface drainage. The width of the grading will depend, of course, on the width of the macadam adopted.

In fixing the grades care must be taken to adjust the cuts and fills so that there will be little or no waste of material. This requires some judgment and experience, since most materials shrink to a greater or less extent when taken from the cuts and placed in the fills. It is estimated that this shrinkage, together with certain unavoidable waste, averages about 15 per cent. When the depth of the fill is but a few inches, the use of the steam roller will often cause a much greater shrinkage.

Grade stakes should be set on both sides of the roadway not more than 50 feet apart longitudinally, with the established grade plainly marked on them. They should be set sufficiently far from the roadway so as not to be disturbed by the grading and other operations. These stakes will serve later for the macadam work.

The road should be graded to the approximate subgrade elevation, with a sufficient surplus of material to form the shoulders. It should also be remembered that the materials will settle to a considerable extent when the steam roller is brought on.

The surface water should always have opportunity to drain from the roadway as quickly as possible, and the gutter grades should be so fixed that there will be at least 6 inches fall in 100 feet. With less fall, if there be snow in the winter, the water will be held back and cause trouble. Deep ditches beside the road are dangerous to travelers and are usually unnecessary. It is a better practice to construct culverts more frequently and to lay pipes connected with catch basins and leading to suitable outlets longitudinally under the road.

No impervious materials, such as clay and loam, should be permitted within at least 18 inches of the top of the completed road, particularly if the road is in a locality where the ground freezes in winter. All stumps and roots should be grubbed out and removed. The clay and loam may be placed on the sides of the road, but such materials should not be permitted under the broken stone. Sand, gravel, or other material which does not hold water should replace them.

Water should never be permitted to remain under a macadam road. It softens the foundation so that the broken stones are forced down into it by the wheels of vehicles, thus causing ruts to develop in the macadam. In freezing it expands and "heaves" the broken stone, destroying the bond between the stones and causing the larger stones to rise to the surface. As a result the material in the subgrade is forced up into the interstices between the stones, and in the spring the macadam will be found to be rough, irregular in shape, and weakened. There are several ways of removing the difficulties with subsurface water, at least in part. Sometimes if the grade is raised in wet places the trouble will be lessened, particularly if porous materials are used.

Side drains may be constructed in the cuts on each side of the road, just outside of the limits of the macadam. (See Fig. 3.) These drains consist of narrow trenches, filled with broken stones or small gravel stones, with a pipe 5 or 6 inches in diameter near the bottom. The pipe is laid with open joints, true to grade, and is carried to a proper outlet. Sometimes the pipe is omitted and the entire trench filled with stones, in which case it is called a blind drain. Such drains serve to cut off the subsurface water before it can get under the macadam. (See Fig. 4.)

A trench of a width identical with the width of the macadam may be excavated for a depth of from 12 to 18 inches in the center and to a depth of from 6 to 8 inches on the sides, shaped on the bottom like a flattened letter V. (See Fig. 3.) This trench is filled with field or any sort of stones, varying in size from the smallest obtainable to such as are 8 or 10 inches in diameter, the largest stones being placed at the bottom. The stones need not be placed with especial care, but yet so as to permit their consolidation by a roller. The bottom of the trench should be tolerably true to grade, and "cut-off" lateral trenches filled with stones are necessary to carry the water to proper outlets. Such a drain is usually effective and ordinarily costs less than two side or blind drains.

Another way of nullifying in part the effect of the subsurface water is to construct a foundation of telford. Formerly, nearly all macadam roads were built with a telford base, regardless of any consideration of the requirements of traffic. It is now generally recognized that, except in unusual cases where the subsoil is full of water which cannot be drained out, the telford base is unnecessary except for purposes of subdrainage. A satisfactory telford foundation may be made by placing vertically on a layer of gravel 2 or more inches in depth, stones of fairly uniform size, not exceeding 10 inches in width, 6 inches in depth, and varying in length from 6 to 20 inches. The stones should be set on their broadest edges, lengthwise across the road, and wedged rigidly into position by smaller stones driven by mauls into the interstices between the telford stones. The projecting points should be broken off with stone hammers, the depressions filled with chips, and the telford rolled with a steam roller until it is true to the desired cross section.

Where the foundation of the road would be otherwise very bad, and no gravel or other like material is readily obtainable, or where an unusually substantial road is required to meet the demands of traffic, this form of construction is recommended. Under ordinary conditions it is much too expensive.

It has been said, and there is some supporting evidence, that a rigid and unyielding telford base has the effect of an anvil, and that the macadam stones, under the pound of traffic, wear more rapidly than in the ordinary broken-stone road.

The care of surface water has already been discussed to some extent. It is obvious that the water which falls on the road and which flows upon it from adjacent lands should be got rid of as soon as possible. Culverts should be built at low points where outlets are available, and existing streams should always be utilized for outlets. The water should never be carried in the gutters or in side ditches any farther than is necessary. When the volume of water is small, it may often be carried across the road in tile pipes buried sufficiently deep so as not to be broken by vehicles upon the road. If it is necessary to lay a pipe within 2 feet of the surface of the roadway, iron water pipe or gas pipe should be used. For larger volumes of water culverts of rubble masonry or Portland-cement concrete may be built. Very often, with a proper design, it will be found to be more economical to use the concrete, particularly if it is reinforced with steel. (See Fig. 5.) Large culverts and bridges should always be designed by competent civil engineers and constructed under their supervision.

In many localities it is the custom to extend to the center of the road driveways leading from adjacent lands to the road to meet its center grade. This practice makes it necessary to carry the gutter water under the driveway in a pipe. Nearly always it is possible, by regrading such a driveway, to make it coincide with the gutter grade, so that the surface water will flow by without interruption. This should always be done when possible. Pipes with open ends laid at the gutter grade are always unsatisfactory, since they fill up quickly with leaves and sand and with slush in winter time, and thus the surface water is forced out upon the macadam and soon gullies it. When a pipe is required, a catch basin should be built on the upper side of the driveway, the pipe should be laid to connect with it, and carried sufficiently far underground to discharge properly into the gutter below the driveway.

In cuts where the grade is in excess of 3 per cent and where the soil is loose or sandy it is sometimes necessary to pave the gutters with cobblestones or with paving bricks or paving blocks to prevent the formation of gullies in the shoulders and in the macadam. Usually a gutter 3 feet in width laid on the same or a little greater slope than the macadam, with an outer row of large stones about 1 foot high laid vertically against the bank of the cut, is sufficient. Such a gutter usually replaces the shoulder, and it should not be constructed until after the macadam is substantially completed.

It is not enough that the roadway shall be graded with reasonable care. The surface upon which the broken stones are to be placed must be hard, smooth, and carefully crowned. If the foundation is not hard and firm the stones will be pressed into it by the roller and wasted. If not crowned, an unnecessary quantity of stone will be used. When the macadam is to be of uniform thickness throughout its cross section, the crown of the subgrade should be the same as that of the finished road. If the macadam is to be thicker at the center than at the sides, a part of the crown will be in the macadam itself and the center of the subgrade should be raised enough to produce the contemplated surface crown when the stones are in place. In shaping, a road machine can usually be used to advantage.

Usually a trough-shaped section is made, sufficient material being left on the sides to form the shoulders for the macadam. If the natural soil is not sufficiently good for shoulders, suitable material should be brought on at this time. The shoulders, in addition to affording a surface for the occasional passage of wheels, serve to some extent to prevent the crowding of the broken stone outside the limits of the proposed macadam roadway during the rolling.

After the roadbed is shaped to the approximate cross section it should be rolled thoroughly until it is hard, firm, and smooth. This is essential, since if the subgrade is soft much of the broken stone will become embedded in it later. Usually it will be found that a steam road roller will do the work more economically than a horse roller and with better results.

If soft places are found or depressions develop in the rolling, more good material should be put on, so that when the subgrade is ready for the broken stone it shall conform to the proposed cross section as nearly as is practicable.

(To be concluded.)

PHOSPHOR-BRONZE.

By Edwin S. Sperry.

The term phosphor-bronze is used to designate an alloy of copper, tin, and phosphorus, or of copper, tin, lead, and phosphorus. The phosphorus is added in small quantities, with the sole object of reducing the oxide of copper, which forms during the melting. Any greater amount of phosphorus than the amount required for deoxidizing the bronze is injurious. The determination of the amount necessary to reduce the oxide of copper is quite difficult, as no two melts of copper oxidize the same. One melt may be heated longer than another, and thus absorb more oxygen. In general, however, it may be said that 0.05 per cent of phosphorus is sufficient. In making castings where scrap is used, it is often advisable to add more than enough to deoxidize the copper. From 0.10 to 0.25 per cent of phosphorus is advisable for this class of work.

Phosphor-bronze may be made in two ways: First, by introducing the phosphorus into a mixture of copper and tin; second, by first introducing the phosphorus into molten tin and making a phosphor-tin. This, in turn, is then added to the copper. The introduction of phosphorus into copper and tin while melted, as in the first process, is a dangerous operation, and accompanied by a loss of phosphorus. Sticks of phosphorus, kept under water to prevent spontaneous ignition, are placed in a bell-shaped arrangement of graphite called a phosphorizer, and the whole is pushed down under the surface of the molten copper. A violent ebullition takes place, with much loss of phosphorus, and danger to the operator. From 20 to 30 per cent of the phosphorus burns, the rest alloying with the copper.

The second process, in which the phosphorus is introduced into the molten tin, to make phosphor-tin, embodies the same processes as those outlined above, except that the phosphorus is first introduced into tin alone. As tin melts at a much lower temperature than copper, the introduction of phosphorus is attended with less danger. The copper is then melted in the usual manner, and the tin, and lastly the phosphor-tin, added.

One of the principal uses of phosphor-bronze is in the form of springs. A good mixture for phosphor-bronze springs is as follows:

Copper	95 parts by weight
Tin	$4\frac{1}{2}$ parts
5 per cent phosphor-tin.	$\frac{1}{2}$ part

For phosphor-bronze of the highest possible strength, the following mixture is recommended:

Copper	90 parts
Tin	9 parts
5 per cent phosphor-tin	1 part

The mixture made according to this formula is poured into ingots, and then remelted and poured into sand castings. The remelting increases the strength. For ordinary work, when a medium strength is required, and when scrap must be used over and over again, the following mixture is recommended:

Copper	90 parts
Tin	8 parts
5 per cent phosphor-tin	2 parts

The scrap from this mixture may be used over and over again, with good results.

Phosphor-bronze, for use as bearings, which is one of the principal uses of phosphor-bronze in machine tool construction, must always contain lead. It is the lead which gives the bearing its "anti-frictional" qualities. The phosphorus prevents the separation of the lead. Lead may be present in the mixture up to 15 per cent, but the majority of makers use less. Tin must be used in the mixture as well. A good, general mixture of phosphor-bronze bearings is as follows:

Copper	80 parts
Tin	8 parts
Lead	10 parts
5 per cent phosphor-tin	2 parts

Zinc should never be present in phosphor-bronze. It causes liquidation and formation of tin-spots in a marked degree. Tin-spots are small, hard, white masses in the interior of the casting. Frequently they are so hard that a file will not touch them. The excess of phosphorus in phosphor-bronze mixtures is also a cause of tin-spots. The secret of success in producing phosphor-bronze, in fact, is simply, in the first place, to keep the phosphor content down as low as possible in consistency with the serving of its purpose, and not to add any zinc.—Brass World.

THE ECONOMIC VALUE OF WATER POWER.

POINTS IN FAVOR OF WATER-DRIVEN WORKS.

In his presidential address at the Technical High School Fredericiana, in Karlsruhe, says the Electrical Review (London), the rector, Prof. Dr. Rehbock, the purchase of whose plans for the Murgthal Barrage by the Baden government has brought the resources of this country for electrical water-power schemes prominently into the foreground, gave an interesting *résumé* of the economic value of water power as compared with the steam-generated power. After tracing the application of mechanical power to the use of mankind from its infancy, the professor laid stress upon the fact that steam-driven, as compared with water-driven, power works present the advantage that they may be erected anywhere; thus costly transmission of power over long distances is avoided, while in many parts of the world, especially in low-lying parts, no water power is available. Another important factor is that heat-driven works can always be utilized to their full capacity, while water-driven works, unless provided with sufficiently large storage reservoirs, have to reduce their output at certain times of scarcity of water supply.

The points in favor of water-driven works are that they are cleaner, do not vitiate the atmosphere, and are less dependent upon the ability or willingness of the staff (practically unaffected by strikes). They are perfectly independent of the difficulties connected with the supply of fuel, and, above all, they produce energy at a low cost.

The cost of the unit of energy is naturally the most telling factor in this comparison. Under the best possible conditions, i. e., when erected near coal deposits and with regular and continuous work, heat-driven power works cannot produce a kilowatt-hour under 0.25 cent to 0.5 cent, equal to 0.38 cent to 0.75 cent at the switchboard. If the demand is subject to great variations, as, for instance, in light and railway supply stations, and when coal has to be obtained from a distance, that cost is often more than doubled. High-pressure water-power works are able to produce the power at one-half or one-third less, and even the low-pressure works, though more expensive, produce power at a much lower cost than it is possible for heat-driven works to do.

In any important power work it is a question of providing many millions—sometimes more than 100 millions—of such units per year, and this means an economic advantage of such great value that it will compensate the mountainous districts, which are rich in water, for any disadvantage they present as compared with the flat country districts.

The countries in which water powers have been exploited in a large way, especially Switzerland, Austria and Upper Italy, have already found considerable profit by their venture. The rapid economic advance in this direction which has taken place in the last few years is, above all, due to the exploitation of the large water powers of the Alpine rivers.

It is at present not possible to say with certainty how far the water powers of any country will be able to cover the energy required. We can approximately estimate the power contained in the flowing rivers of some parts of the world's surface, where we know the area of the country, average height above sea level, evaporation and rainfall, and quantity of water flowing into the sea. What part of this theoretically available material can be put into practical use cannot be estimated exactly without devoting to it a study and labor requiring much time, as the relation of the available supply to the production of energy varies very largely, and is dependent upon local conditions, supply of fuel, etc.

Theoretically, the energy of the flowing waters on the world's surface aggregates 8,000 million horse-power, or 143 horse-power per square mile, and 5 horse-power per inhabitant. In Germany these figures represent a total of 16,000,000 horse-power, or 80 horse-power per square mile, and about 1¼ horse-power per inhabitant. The Grand Duchy of Baden possesses, quite apart from the power derivable from the Rhine, 1,000,000 horse-power, equal to 172 horse-power per square mile, or ½ horse-power per inhabitant. The power obtainable from the Baden shore of the Rhine would increase these figures to 2,600,000 horse-power; 445 horse-power per square mile, and 1¼ horse-power per inhaitant. This means that Germany has only half of the world's average, while Baden has more than three times as much as far as area is concerned, although the density of the population reduces the figures to 1¼ horse-power per inhabitant. In consequence of its mountains, heavy rainfall and the Alpine waters coming down the Rhine, the Grand Duchy of Baden is comparatively very rich in water power.

Although no reliable estimate can be made of the world's power supply derivable from water power, it is certain that there exists more than sufficient to supply all needs. Even taking the utilizable quantity at one-sixteenth of the total, an estimate which is really much too low, there will be 500,000,000 horse-power, or 9 horse-power per square mile, which is ten times as much as the equivalent of the 1,000 million tons of coal, the demand on the coal resources in 1907. This is a most satisfactory circumstance, as the coal deposits of many civilized countries may be said only to be sufficient for the lifetime of a few generations, while the large deposits of China will only last for another few centuries if the demand keeps on increasing at its present rate.

While thus the world's supply is assured, the conditions in the different countries are very different. The apparently available supply of 2 to 2.5 million horse-power in Germany is not equal even to the present demand. Among the German States, Baden takes the first place with about eight times of available power, while it is only second to Switzerland as regards all European States, and with the development of Lake Constance it could be made to take the first place in Europe among the countries possessing water power.

At a low estimate, the cost would be 0.5 cent per horse-power per hour in unregulated high-pressure works and in the case of exploiting the Rhine, where the installation is costly, but where, on the other hand, the supply fluctuates very little. In high-pressure works regulated by storage reservoirs the cost would be 0.25 cent per horse-power-hour; those works may be estimated to cover 25 per cent of the total. The total water power available in Baden, at a rough but low estimate, represents an annual profit of $3,000,000 on a capital of $75,000,000. This represents a saving of two million tons of coal, or $7,500,000, and each 25 cents rise per ton of coal means a further saving of $500,000.

According to Mr. H. M. Wilson, in a recent issue of Power, there is now a total of 4,500,000 horse-power in the United States developed from water sources, and the investigations by the government lead to the belief that this can be increased to 10,000,000. The water resources branch of the Geological Survey is studying the water supplies of the country, with a view to ascertaining their availability for the production of power for the irrigation of arid lands, or the draining of swamp lands and for domestic uses. Its work will result in conserving the water supply by the construction of reservoirs for the storage of flood and the increase of dry-season discharges.

As yet, no estimate of even an approximate nature can be made of the water flowing perennially in our streams, or which may be impounded in storage reservoirs, and which may be made available for utilization in generating power. It is well known that but a small proportion of the available water power in the streams is as yet so utilized. Unfortunately no statistics have been gathered of the present condition of the development of water powers or their future possibilities. The following approximate data are presented in the light of the knowledge of the topography and hydrography of the United States, garnered from employees in various branches of that service.

In New England there is developed 1,000,000 horse-power, and there may be ultimately available for power purposes a total of 1,500,000 horse-power. In the Great Lakes region the present development is 1,250,000 horse-power with a possible development of 4,000,000. In the Piedmont region on the Atlantic and south Atlantic slopes, 1,250,000 horse-power is now developed, with 3,000,000 possible of development. In the central Northwest 500,000 horse-power has been developed, with a total of 1,000,000 possible. In the Rocky mountain and Pacific regions there is now 1,500,000 horse-power in operation, with 5,000,000 possible. In consequence of the water resources branch there has been added in recent years nearly 1,000,000 horse-power from water sources. All this power is of value in performing its share of conserving the fuel supply of the country.

A good example of how the development of one industry helps another is found in an order for manganese steel disks recently placed in Milwaukee. This firm, in addition to manufacturing magnetic clutches, makes a specialty of lifting magnets for handling pig iron and scrap metal. The growth of this latter business and the natural desire of the manufacturers to perfect every detail of their product has led to the adoption of manganese steel for coil shields—the coil shields being the flat disk fastened to the under side of the lifting magnet for the double purpose of protecting the magnetizing coil and interposing between the two poles of the magnet an area of non-magnetic material. Brass, which is non-magnetic, has heretofore been used for this purpose. Ordinary steel will not do, because it is a magnetic metal and would serve to conduct the magnetic lines of force from pole to pole instead of compelling them to seek a passage through the material to be lifted. Manganese steel seems to be the ideal metal for this purpose. It is non-magnetic, like brass, and infinitely harder—so hard, in fact, that the continued hammering of the pig iron or other metal on the under surface of the magnet makes not the slightest impression on it. The 50-inch magnets recently furnished to a number of steel mills in the Pittsburg district are all equipped with manganese steel coil shields instead of with the brass coil shields formerly used.—Machinery.

RECENT DEVELOPMENT OF THE GAS TURBINE.

By Alfred Barbezat.

The first experiments with gas turbines were made with a small turbine of the same type as the De Laval steam turbine, capable of developing about 30 horse-power, and after noting the performances of this machine when driven by compressed air alone, arrangements were made to use it in connection with a combustion chamber, delivering the products of the combustion of liquid hydro-carbon fuel at constant pressure through a nozzle upon the blades of the turbine. The combustion chamber is provided with a refractory lining, and in dealing with such high temperatures of combustion as are met with in engines of this kind, the temperature of combustion being over 3,200 deg. F., the best refractory lining has been found to be carborundum, this material being a product of the electric furnace, and thus having already sustained a higher temperature than that in the turbine combustion chamber. An elastic backing of asbestos provides for the expansion of the carborundum lining. The nozzles through which the cases are discharged are also made of carborundum. In addition to the refractory lining, the combustion chamber must be provided with a water jacket in the form of a coil of pipe imbedded in the metal of the chamber walls. When the water has circulated in the jacket tube, it is sent through small holes into the combustion gases just before they enter the nozzle, and the water is there converted into steam which acts to lower the temperature of the issuing gases to a point where they will not injure the blades of the turbine.

In order to obtain the desired result of a machine involving only rotary motion, it has been found necessary that the compressed air, by which the combustion chamber is fed, should be produced, not by a reciprocating combustion compressor, but by some form of rotary motion, preferably so arranged that it can be coupled directly to the turbine itself. This means that the complete gas turbine must also include a rotary air compressor, and that such a compressor must have a high efficiency in itself, otherwise it will produce such a large proportion of negative work as to detract materially from the efficiency of the compound machine.

After several experiments, a multiple turbine compressor was decided upon, which was found to be capable of delivering one cubic meter of air per second, at a pressure of six or seven atmospheres, with an efficiency ranging between 60 and 70 per cent. A large-sized gas turbine has been built, and in this machine the compressor is found to absorb about one-half of the power developed by the turbine. The machine when running at about 4,000 revolutions per minute develops about 300 horse-power over and above the negative work absorbed by the compressor. It is stated, however, that the thermal efficiency of the machine is not as yet as high as that of a reciprocating gas engine. During the past few months a practical application of the gas turbine has been made in connection with the operation of submarine torpedoes. The turbine made for this purpose developed 120 horse-power at a speed of 1,000 revolutions per minute. The weight of the turbine alone is about 2.86 pounds per horse-power.

While the gas turbine is, of course, still in its experimental stage, it has made a material advance during the past year, the 300-horse-power compound compressor turbine being an accomplished fact, and a number of 120-horse-power machines of special type being actually installed for service. When this rate of progress is compared with the time required to bring the reciprocating gas engine to its present state of perfection, there appears to be a reason for encouragement and interest in this form of gas engine.—Cassier's Magazine.

THE GREAT PEARL OYSTER.*

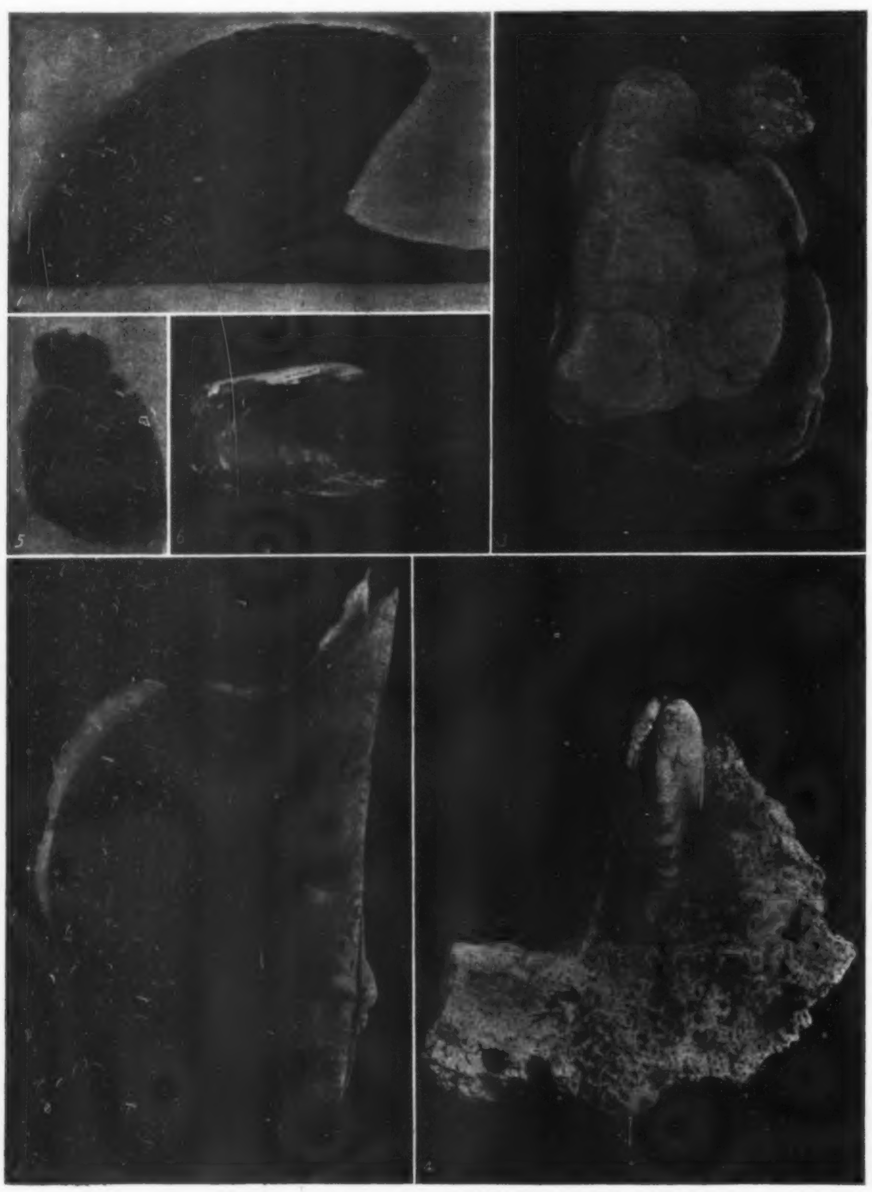
SOMETHING ABOUT THE MOST PRECIOUS BIVALVE.

The Great Pearl Oyster (*A. margaritifera*, Lam.) better known to the commercial world by its sub-generic surname, Meleagrina, is a wing shell with wings reduced to small angular projections near the hinge of the large, flat circular valves. The outside surface shows a coarse, laminated structure, of dull olive to smoke color. Within, the thick pearly lining is a beautiful, iridescent expanse, interrupted by a central muscle scar.

When small, the valves are ribbed and wear a luxuriant growth of long, flat scales, twisted and curved like fronds of coral. These disappear as the shell grows larger and thicker. At maturity it is often ten to eighteen inches across and surprisingly heavy.

Pearl oysters live in tropical seas on clean, sandy bottoms fifteen to twenty fathoms down. The strong byssal cord thrown out through the hinge anchors the mollusk to coral masses or to other shells, whence they never move until brought up by divers. These are the bivalves which for centuries have furnished the precious "oriental pearls" adding constantly to the treasure of kingdoms and individual collectors.

Mother-of-pearl, the thick lining of each valve, is the dependable produce of pearl fisheries. It is secreted in annual layers by glands in the mantle. There is just enough animal substance in it to support the particles of lime carbonate. The iridescence is due to microscopic undulations of the various layers which compose it. These layers expose oblique edges to the surface, and the refraction of light produces the rainbow colors.



WING SHELLS, ROCK-DWELLERS AND A MUSSEL

1 Great-winged Avicula, *Avicula macroptera*.
2 Atlantic Wing Shell, *Avicula Atlantica*.
3 Peruvian Wing Shell, *Avicula Peruviana* with byssus.
4 Rock-eater, *Lithodomus lithophagus*, in its burrow.
5 Rough Rock-dweller, *Vulsella rugosa*, embedded in porous rock.
6 Tulip Horse Mussel, *Modiola tulipa*.

The best mother-of-pearl comes from healthy, full-grown shells; the finest pearls from shells distorted by crowding and disease, and invaded by parasites and foreign particles. The first is a natural growth; the second abnormal. A lusty, well-fed mollusk, enjoying life, has a neighbor, warped, debilitated, suffering, with a grain of sand rolling around in its mantle folds. Coat after coat of nacre is added to this irritating foreign body to lessen its injury to the tender flesh. When the diver finds it, a magnificent pearl, it makes him rich. Only one shell in a thousand, we are told, contains a gem of any value. So the lines of Browning would do little, I fancy, to reconcile a discontented pearl-diver to his hard lot:

> There are two moments in a diver's life:
> One, when a beggar, he prepares to plunge;
> Then, when a prince, he rises with his pearl.

Throughout the seas of the equatorial regions are scattered pearl fisheries where thousands of people are engaged in diving for the pearl-bearing mollusks. Ceylon has ten, operated under government control. Nearest to us are the Panama and Lower California fisheries. Four to five thousand boats manned by divers work in the Persian Gulf each summer. The harvest of one year in this locality alone adds to the world's wealth in gems and mother-of-pearl $2,000,000. This is the average, according to official statistics. The shells are smaller, but of better grade than those of Tahiti and of Panama. Australian fisheries produce small but very brilliant pearls. The Pacific Islands have many fisheries, noted the world over for their gems. The most famous pearls come from the Sulu Islands. Tahiti is the center from which the products of the South Pacific fisheries are exported. Amsterdam, Hamburg, St. Petersburg, Paris and London are the great markets for these. Bagdad is the chief market for white seed pearls from the Red Sea and Persian Gulf. Bombay distributes round pearls of yellowish color, for which Hindus have a preference.

White pearls are the most valuable, outranking yellow, green, pink and gray ones which are also held in high esteem, especially when two or more are perfectly matched. Globular pearls, free from flaws or discoloration, bring the highest prices. Pearl-shaped ones rank next in value. Any form, so it be symmetrical and pleasing, is acceptable. Perfect pearls increase in price in geometrical ratio with increased weight and size. Pearls are not worked or polished, as most gems are. They are very soft, with a luster nothing can improve.

No shells under five years old contain pearls of value. The growth of the sixth year doubles their value in mother-of-pearl. The seventh year again doubles it. The restriction of fishing protects these young mollusks, and prolongs the life of the industry which, when unrestricted, exhausts the beds. In many places diving suits are never used, and dredging is forbidden by law. A famous Chinese fishery is worked one season, then it is left undisturbed for ten or fifteen years.

The pearl fishery at Bahreim on the Persian Gulf calls together for the spring season, March, April and May, thousands of persons. The divers bring their families, and build huts of palm and bamboo. Boats carrying fifteen to twenty men go daily to the banks which lie under ten to twelve fathoms of water.

The diver is naked, his body rubbed with oil. He stuffs his nose and ears with cotton. A clamp is often worn on the nose. He carries a knife to fight off sharks, and to loosen the oysters. A basket hangs on his neck. He has a bar with a large shot at each end under his feet. He is framed by three wooden pieces attached to the loaded bar. A rope lets this frame down and hauls it up in two minutes or less time. The diver has about seventy-five oysters. Fifty times a day he will take the trip.

The two great afflictions of divers are rheumatism and ulcers. The reward of this exhausting form of labor is a fluctuating, elusive thing. The uncertainty of it does not lessen its hold on the people who take it as a matter of course. The Ceylon fisheries give the diver one-fourth of his shells, divided when he comes up. Another plan is to pile the shells until they open, when the soft parts are thoroughly scanned for free pearls, which are the most valuable, and the shells are cleaned for shipment as mother-of-pearl. At this time the diver gets his share.

In one of the best-managed fisheries in the South Sea Islands the divers work by contract that binds them for the season. They are paid by the ton for their shells, graded into three qualities. The pearls found belong to the divers, who sell them usually to the company. The best grounds are near the bases of large patches of coral, at ten to fifteen fathoms depth. Women and children make expert divers. All get excellent wages, which they squander upon tawdry finery at the company's store, and Saturday and Sunday are spent in carousing.

The "Albatross" on a recent cruise spent some time near this pearl fishery, and one of the party gives a vivid account of a visit to see the divers at work.

"We took passage in one of the small cutters employed in the fishery, and on arriving at our destination made fast to a cutter anchored over a submerged growth of coral. Two other cutters were anchored close by. Three divers were on one boat and five on the other, one of whom was a woman. Each of the divers is provided with a water glass with which he scans the water before going down. The glass is sixteen inches square at the top, twelve inches at the bottom, and twelve inches deep. (A hollow cubical vessel.) It has a notch in the side in which to rest the neck. By its aid the bottom can be seen to a depth of twenty fathoms, and shells located. By locating clumps of shells before going down, much labor is saved. Instead of the diver exhausting his energy in diving at random and searching for shells after reaching bottom, he goes directly to the spot where the shells lie. At other times, in shallow water, he goes down to explore the bottom. In this way clusters of shells are located before any are taken.

"Before descending, the divers sit around on deck for some little time, inflating their lungs to the fullest capacity, exhaling the air through the mouth, making a low, whistling sound. No clothing is worn except a breech cloth. On the shoulders is carried a bag net in which to put the shells. It is made of cocoanut fiber and is about twenty inches deep and twelve inches across; size of mesh, 2¾ inches. It offers little resistance and will carry all the shells a man

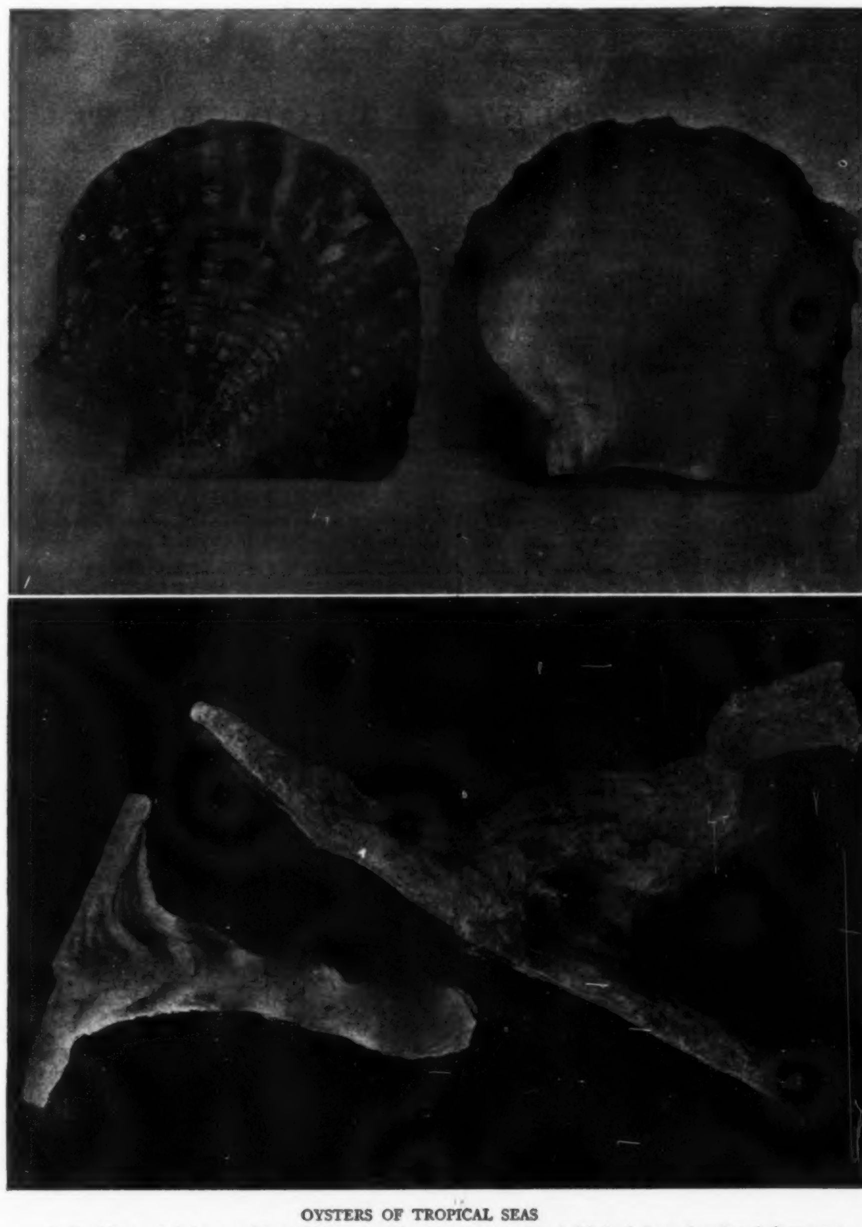
* From the Shell Book. By Julia Ellen Rogers. Illustrated with 8 plates in color and 96 full pages in black and white from photographs. New York. 1908. Doubleday, Page & Co. Quarto. Pp. 485. Price $4.

can bring to the surface. In the left hand is carried a pearl shell, which serves the same purpose as a knife. With it obstacles are removed from the bottom and shells are loosened from their bed. The right hand is protected by a white cotton mitten.

"When ready to descend, the diver slips over the side of the boat, holding to the rail with one hand and holding the water glass in the other. Locating some particular point at the bottom, he lets go of the rail, drops the glass, takes a deep breath and sinks out of sight, feet foremost. Descending about ten feet, he quickly turns head downward, and swims to the bottom. When hardly a third of the distance has been reached, he has the appearance of being on the bottom, so transparent is the water. On reaching it he places himself in a horizontal position, seemingly hauling himself along from one point to another.

"One man consented to give an exhibition dive in deep water. The cutter was dropped off a short distance from the shoal, and a sounding made in seventeen fathoms (102 feet) of water. We watched through water glasses the diver's movements from the time of sinking below the surface until rising to the top again, two minutes and forty seconds.

"Reaching his destination, he began picking over pieces of coral, brushing aside broken shell and other debris in the same manner as if he were working in a garden. He investigated the bottom for some sixty or seventy feet from the initial point of landing. When ready to ascend he stood erect, and came up as if being pulled with considerable force, shooting out of the water half-way to the waist. He seemed to suffer no unusual discomfort, and in a short time was ready to go down again. There is a record dive of twenty-three fathoms."



OYSTERS OF TROPICAL SEAS

1 Pearl Oyster, *Avicula margaritifera*, which produces the Oriental pearls. The shell lining is the mother-of-pearl of commerce.
2 White Hammer Oyster, *Malleus albus*. 3 Common Hammer Oyster—*Malleus vulgaris*.

MYCENAEAN CIVILIZATION.*

By Prof. James Rignall Wheeler.

Until recently the island of Crete, which appears to have been the chief center of the Mycenaean civilization, was politically in too unsettled a condition for very extended archaeological work. This, however, did not prevent Dr. Arthur Evans from studying it, and largely through his great knowledge of the small objects, especially the gems, which illustrate the early art of the Aegean, and which have been found in many places, he was led to form conclusions in regard to the probable results of excavation in Crete, which, now that they have been abundantly confirmed, are seen to constitute an extraordinary example of archaeological penetration. Dr. Evans's excavations at Cnosus, near Candia, are the most extensive that have thus far been prosecuted in Crete, but those of the Italians are extremely important also, and they have yielded some of the most interesting specimens of Mycenaean objects. The excavations at Cnosus, however, have revealed a very long chronological sequence, which appears to begin as early as the earlier Egyptian dynasties, toward the beginning, that is, of the fourth millennium B. C., unless indeed a still earlier dynastic dating be accepted. The changes in Cretan art can be traced from this point down to the close of the Mycenaean time, that is, till about the end of the second millennium B. C. To the Greek archaeologist it is the objects which belong to this second millennium that have the most immediate interest, because of their relation to Mycenaean art, but those which are to be dated earlier are of the highest importance to a knowledge of that which lies back of the Mycenaean period. It has already been said that Schliemann found settlements at Hissarlik beneath the one which proved to be the Troy of Mycenaean times, and evidence of this primitive culture has for years past been turning up in the islands of the Aegean. Just now similar phenomena are appearing on the Greek mainland, notably under the ruins of Mycenaean Tiryns, so that a primitive archaeology of the Aegean region is slowly developing.

The view which archaeologists are at present inclined to take with reference to the Mycenaean civilization is that one of its greatest centers, probably its greatest center, was in Crete, and that a period in its course of great influence and power is to be associated with the King Minos who becomes an important figure in later Greek legend. Whether the civilization spread directly from Crete to outlying regions is still a matter for discussion. It was important in Sicily, and its influence reached to far-off Spain, which in its bullfights appears still to hark back to a favorite Mycenaean sport. Some students of the prehistoric archaeology of northern Europe believe indeed that this Mycenaean influence may be traced far northward into the continent. The regions, however, that were close at hand must have felt this influence most strongly. Thus to understand the ethnic and artistic relations in which this early civilization stands to the Greece of later times is all-important to the Greek archaeologist.

The art of the Mycenaean civilization was in some directions of a very fully developed type. In architecture we find exceedingly elaborate structures, especially in Crete, where the palaces of the chieftains were unfortified, presumably because their owners controlled the seas. On the mainland, the palace at Tiryns shows most distinctly the type of the fortified residence, and here we approach a good deal more closely to the plan of a chieftain's house as it appears in the Odyssey. It is clear enough that these residences were often splendidly adorned and were arranged for a life of considerable comfort. Wall paintings of high decorative merit have been found, excellent relief-work in plaster and fine carving in stone, but it is above all the objects of minor art which excite our admiration. Some of the work in gold, silver and bronze has perhaps never been surpassed, and great skill, too, is shown in the relief work on some of the stone vases, and in the carving of ivory and gems. In pottery, too, there is very high development, and great variety, with extremely clever use of plant forms and of some marine animals in the decorative schemes. A linear script which takes the place of an earlier hieroglyphic writing was known, but it has not yet been deciphered. In general it may be said that the Mycenaean art shows some oriental and especially Egyptian influence, but in the main its character is singularly independent, and it is often startlingly modern, much more so than the Greek art of the classic period. When the human face is represented, it is neither Egyptian nor Semitic in type, and the individuality of the faces is strongly marked. To me it seems that great emphasis should be laid on this tendency to mark the individual. The importance of the individual man is one of the leading social facts of Greek civilization, and one of the features which distinguishes it from the characteristic civilizations of the East. Thus when the differences between the art of Greece and that of the Mycenaeans are emphasized, it is well to keep this fundamental resemblance in mind.

But what is the origin and what are the ethnic relations of this gifted people which has so recently been made known to us? This is a question now being eagerly asked, but as yet it has not been answered. If the writing on seals and clay tablets shall be deciphered, we are likely to know a good deal more than we do now. At present the whole matter is involved in the conflicting traditions regarding the various tribes and peoples which had their homes in Greece before the inhabitants came to be known as Hellenes, for, if anything is certain, it is that the Greeks of historic times were a mixture of various different peoples. The problem becomes closely linked with the intricate question of the origin of the Homeric poems, since in them we have a picture of the heroic, or Achaean civilization which furnishes the background for so much of Greek legendary history. More specifically, the question presents itself to us in this form: Is the Mycenaean art and civilization sufficiently like the art and civilization depicted in the Homeric poems to warrant us in practically identifying the two civilizations? It is not surprising that archaeologists should often disagree in such a matter, and of course the extraordinarily difficult critical problem of the unity of the Homeric picture is also involved. Is it a single picture that the poems give us, or is it a picture of earlier times complicated by the contemporary influence of the poet's surroundings or by the play of his own fancy? Clearly there is plenty of chance for a difference of opinion, and two marked tendencies are observable. The one would emphasize the differences between Homeric art and that of the Mycenaean civilization, the other the resemblances between the two. As matters stand to-day, the view that the Homeric poems reflect in the main the civilization of the Mycenaean period is the prevailing one. The differences, it is thought, may generally be explained by the fact that the poems originated at a later time, and that the picture they give has been somewhat modified by changing customs. Thus the society of the poems has a somewhat more democratic stamp than we should naturally associate with the Mycenaean civilization, and the connection between the Homeric conception of the gods and the religious ideas of the Mycenaean civilization, so far as we can form an idea of them, is not yet clear. Apparently the muse who

* Abstracted from a lecture on Archaeology, delivered at Columbia University in the series on Science, Philosophy and Art.

inspires the poet is a very complicated personality. Emphasize as we will the unity of the poems in their present form, there is still very strong evidence that they are not chronologically homogeneous in all their parts, and this fact must of course warn us to expect a lack of unity in the picture they afford.

When it is sought to associate the Mycenaean remains with one or other of the various peoples or tribes which appear in the Homeric poems and in other Greek tradition, we are face to face with a somewhat different phase of the problem. For Homer, the Achaeans are the leading race, but we have in Greek tradition conflicting accounts of Pelasgians who were very likely earlier. Homer knows, too, of other races, and in Crete he enumerates many tribes. But so long as we lack the knowledge to form any clear conception of the qualities of these different races, there is no great scientific gain in identifying one or the other with the Mycenaeans. It is always possible, moreover, and very likely, that this wonderful art grew up in the gradual union of tribes of different stock. So, to solve the problem, we must wait for more light.

The relation of Mycenaean art to that of later Greece may, however, be traced in a more distinctly archaeological way, a way that does not involve the uncertainties of vague literary traditions. Here the question is: How far can the influence of Mycenaean design be traced in later art? When this great civilization passed away, at the end of the second millennium B. C., it was succeeded by a period in which artistic design was based chiefly on geometric forms. The art of this period is far less advanced, and we have what has been called the time of the Greek "Dark Ages." Some movement of peoples, very likely the so-called Dorian invasion, put an end to the power of the Mycenaean chieftains, and to the art that their civilization produced; then there was gradually developed an art, ruder in character, which had its basis in the geometric designs that are common enough among all primitive peoples. In other words the geometric art is the outgrowth of a peasant style, a *Bauernstil*, as the Germans call it. In this may be traced some remains of Mycenaean influence, enough, probably, to show that the traditions of that civilization were not quite lost, though investigations in the matter are by no means complete. Another and probably stronger support for this connection between Mycenaean art and that of later Greece lies in the early art of Ionia, where it would seem that Mycenaean elements have been somewhat more directly preserved. As yet, however, we know comparatively little of the early Ionic remains, and their future discovery and investigation is one of the most important problems in Greek archaeology. To the work, then, of the Greeks of Asia Minor we must look for light on this point, and indeed this region of the Greek world has in many ways become the land of promise for the archaeologist. To take but a single instance: in the Greek art of the seventh and sixth centuries B. C. there are many oriental elements. Where do they come from? Very likely through Lydia and Cappadocia, but the early art of these countries is still very imperfectly known.

ARTIFICIAL DIAMONDS.*

PRESENT METHODS OF PRODUCING THEM.

For some time past the daily press has been interested in the production of diamonds artificially. Long articles have been written upon the subject, and various persons, scientific and otherwise, interviewed, owing to the prosecution of M. Lemoine by Sir Julius Wernher on account of his failure to produce diamonds by chemical means after he had stated he was able to do so, and, in fact, had promised to produce diamonds of very large size at a price which would compete readily with the natural product. However, after obtaining large sums of money to build a factory, and apparently carrying out experiments in which small diamonds were supposed to be obtained, M. Lemoine entirely failed to produce large ones. When diamonds said to have been produced in the crucibles were critically examined, experts were able, not only to assure the magistrate that these diamonds were not artificial, but were also able in several cases to identify them as stones which had been bought from known sources. The whole case hinged upon a certain envelope which was originally lodged in an English bank, and in which it was stated a formula was contained by means of which diamonds could be produced artificially. On Tuesday, June 16, this envelope was to be opened before the magistrate, but in the meantime the modern alchemist had vanished. When the letter was opened, according to the Times of June 18, the following particulars were found:

"I, the undersigned, Henri Lemoine, declare that to make artificial diamonds, it is sufficient to employ the following process: (1) Take a furnace; (2) take some powdered sugar carbon; (3) place the carbon in a crucible; (4) place the crucible in the furnace and raise the temperature to from 1,700 deg. C. to 1,800 deg. C. in order to obtain crystallization; (5) when this high temperature has been obtained apply pressure to the cover of the crucible. The diamonds will then be made, and it remains only to take them out."

From this it will be noticed that the formula contains absolutely nothing new; sugar carbon, being the purest form of amorphous carbon, has always been the starting product when any successful attempts to prepare diamonds have been made. Consequently those daily papers which ridiculed the process because of the fact that sugar carbon was one of the ingredients, showed want of knowledge of the subject. However, now that the whole formula is made public, it is, to say the least of it, absurd.

It will be noticed that the carbon is to be placed in a crucible and heated to from 1,700 deg. C. to 1,800 deg. C., and then pressure is to be applied to the cover of the crucible. When, in 1896, Moissan succeeded in obtaining diamonds artificially, he did subject sugar carbon, when at a very high temperature, to a very great pressure. It will be remembered that sugar carbon was dissolved in molten iron, and the crucible containing this was heated to a temperature of 3,000 deg. C. to 4,000 deg. C. While at this high temperature the crucible and its contents were plunged into cold water or mercury in order to cause rapid solidification. When carboniferous iron is cooled, it expands in the act of solidifying. By suddenly quenching the iron, a solid layer or crust is obtained outside the molten metal; consequently when the inside layer commences to solidify it expands, and thus, as it is encompassed with a solid crust, enormous pressure is exerted. On dissolving away the iron by means of acids, minute crystals of diamond were produced.

About the same time Marjorana, by heating a small piece of carbon in an electric arc and then suddenly compressing it by driving a piston down upon it with enormous force, the force being produced by firing a charge of powder in the piston chamber (Nature, June 7, 1900), also obtained minute diamonds.

In 1905 Sir Andrew Noble exploded cordite in closed steel cylinders, when it was calculated that a temperature of 5,100 deg. C. was obtained and a pressure of 50 tons per square inch. Sir William Crookes examined some of the carbon deposited, and found it to contain minute diamonds. It would appear, therefore, that M. Lemoine exploited results well known in the scientific world in order to deceive people engaged in the diamond industry.

It is a rather remarkable fact that although amorphous carbon can be converted into graphite, and diamond may also be converted into graphite, as was recently shown by Parsons and Swinton, who obtained graphite from diamond by rapid bombardment with cathode rays, it does not appear possible to convert graphite into diamond. It has been found that when amorphous carbon and graphite are heated to a temperature of 3,600 deg. C. in the electric arc in an atmosphere incapable of acting chemically upon carbon, they vaporize without first liquefying, and on cooling condense to form crystals of graphite. Diamond, on the other hand, is first converted into graphite, then vaporized, and on condensation forms graphite. It thus appears that carbon must be in a dissolved condition, and must be cooled under pressure in order for a diamond to crystallize out. Possibly, therefore, we shall never be able to obtain the conditions necessary for producing large diamonds in the laboratory. Low down in the earth's crust carbon may be dissolved in iron or other substances, and may at high temperature be subjected to enormous pressure, such as we, even with the wonderful machinery at our command, and capable of exerting pressures of thousands of tons, have not contemplated. In the earth also the cooling while under this pressure will be slow, and therefore there are the conditions necessary for the growth of large crystals.

Although in nature diamonds are found in pipes of blue clay, this is apparently not the magma in which crystallization originally took place, for the diamonds may have been forced into the clay by volcanic agencies. Actual blocks of one of the original rocks in which crystallization took place have been found in blue clay. These blocks consisted of an eclogite containing large quantities of iron, and small diamonds were found, thus suggesting that such was the original mode of formation of the diamond.

* Nature.

RUSSIA'S ARCTIC EXPEDITION.

Three years ago this summer fifteen Russian vessels sailed along the Arctic coasts of Europe and Asia as far as the mouth of the Yenisei River laden with railroad iron and other heavy supplies. Some of these vessels, with barges in tow, took the cargoes up the great river that same season as far as Yeniseisk, within 175 miles of the Siberian Railroad.

It was a bold undertaking, a great success and the pioneer effort of the Russian government to demonstrate the practicability of a new route to inner Siberia through the ice sea and up the Yenisei to Krasnovarsk on the transcontinental railroad.

The detailed report of this journey, which will rank in history as the greatest Arctic voyage up to the present time having the study of transportation and commercial possibilities in view, was published in Russian by the Ministry of Communications in a volume of ninety-four pages with photographs and a map. This work has now been made available for the world at large by Mr. Edouard Blanc, who has published in Annales de Géographie of Paris the gist of the whole report and a literal translation of parts of the diary of events. A brief summary of the voyage and a statement of the conclusions reached by the Russian Ministry with regard to the prospects of this route are given.

The ships were on their way at the time the treaty of peace with Japan was signed at Portsmouth. For two years Russia had seen the Siberian Railroad overtaxed in the effort to transport troops and supplies to the scene of war. The ordinary business of the line had been entirely suspended. There was reason to believe from the voyages of Siderof, Sibiriakof, the English Capt. Wiggins, and Nordenskjöld that any amount of freight might be landed every summer at the mouth of the Yenisei in Siberia. The existing information as to the navigability of the Yenisei encouraged the belief that this freight might be carried up the river many hundreds of miles to Krasnovarsk, some hundreds of miles east of the western terminus of the Siberian Railroad.

In April, 1905, at the instance of Prince Hilkof, the chief of the Department of Railroads, a commission was appointed, with Hilkof as president, to test the practicability of this route on a large scale. The work was carried on with enormous energy. Not a moment could be lost if the vessels were purchased, loaded and dispatched in time to cross the Kara Sea in the navigable season.

Twelve of the largest ports of northwest Europe were ransacked for vessels of suitable tonnage and construction. Fifteen were purchased in a few weeks and were on their way to the Baltic for their loads of iron, coal, and other supplies. As fast as they were loaded they steamed away to Alexandrovsk, Russia's Arctic port on the Murman coast nearly due north of St. Petersburg, which was chosen as the rendezvous. Seaworthy barges were sent in tow to be used in carrying a part of the freight up the Yenisei. Two ice breakers were added to the fleet, but only one of them went through to the river.

The vast work of preparation went on without a hitch and the entire fleet was collected at Alexandrovsk in the second week of August. On August 16 the journey was renewed. By the time the vessels reached the Yenisei they had steamed 2,600 miles from the Baltic, where they took their cargoes. The fleet was divided into sections under separate commands and throughout the voyage they were usually within sight of one another.

It was an eventful journey, but there was little delay. It is surprising that every ship in that venture excepting the ice-breaker and some German barges that turned back arrived at Golkochicha, at the mouth of the river, practically without an accident. They passed unscathed through the ice impediments of the Kara Sea and reached the Yenisei on September 9. Here they were met by a river fleet, to which, supplemented by the sea barges, the loads were transferred by a large party of workmen brought down from the Siberian Railroad, and in three days the fleet was on its way up the river.

The progress up the Yenisei was slow, but under the circumstances remarkable time was made all the way from Alexandrovsk to Yeniseisk. Only the crudest charts of the Asian coast line were available. The ice conditions were imperfectly understood. The lower part of the river was almost unsounded. No pilot had an adequate knowledge of the river navigation, and

there was not a single buoy to mark the course that deep laden vessels should take in the ascent. The fleet had to pick its way. It is a wonder that all the vessels reached Yeniseisk in safety, but the entire fleet tied up there safe and sound on October 23. They had passed safely through the rapids of Osinovskii, but when they reached Yeniseisk the river was full of ice and it was deemed useless to attempt to make the remaining 175 miles up the river to Krasnovarsk on the railroad. If the aids to navigation along the Arctic coast and in the river which the Russian government has now supplied had then been available it is believed that the journey would have been made in two-thirds of the time and the goal of the expedition would have been reached that fall.

The report says, in conclusion, that the voyage demonstrated the practicability of this Arctic sea route for commercial navigation from the Murman coast to the mouth of the Yenisei for two months to two and a half months in the summer season. The wide channels opened between the ice and the coast in Barents Sea in summer always afford good navigation to the Kara Sea. The difficult part of the voyage is in the Kara Sea, but according to our present knowledge the route is always open along one of two passages across this expanse during the two to two and a half months that there is any possibility of making the journey.

The shallowest parts of the estuary of the Yenisei have a depth of at least twenty-three feet and the channel of the river as far as the rapids of Osinovskii is even deeper, so that large ocean vessels may ascend it and discharge their cargoes at any point on the lower river. For more than 600 miles the river has a depth of over twenty-five feet. All that is necessary is to canalize the river around the rapids, to train good pilots and supply an adequate number of buoys to make the whole river to the Siberian Railroad available for European commerce during the season of navigation. This work is now being carried out. It is intended to put this new route into practical operation.

Relying upon the reports of explorers that the sea route along the Asian coast to the east of the Yenisei is much less difficult than to the west of it we now see the Russians contemplating a voyage through the northeast passage in order to demonstrate if possible the practicability of using this far shorter route as a sea connection between St. Petersburg and Vladivostok. —The New York Sun.

PRESERVATION OF FOODSTUFFS.

HOW NITROGEN AND PRESSURE MAY BE EMPLOYED.

BY DR. P. MARTENS.

The preserving property of nitrogen was made known generally for the first time at the International Exposition at Paris in the year 1900, when fish were placed on exhibition which had been preserved for seven years under nitrogen, without having spoiled.

The complete elimination of all atmospheric air from the vessels intended to serve as preserve-containers is naturally bound up with certain difficulties, which would seem to indicate that for the present the general utilization of this method is rather improbable. Elwood Cooper, the State Horticultural Commissioner of California, has, however, for the preservation of fresh fruit, solved this problem in a practically applicable manner. The method is somewhat as follows: Paper boxes treated with bitumen, in order to prevent the penetration of air from the outside, are used as containers. After the boxes have been filled with fruit, they are closed, except for a very small opening. A number of these filled boxes are placed in a steel cylinder, from which the air is then completely exhausted. Thereupon the cylinder is filled up with pure nitrogen, and the boxes closed by means of an automatic appliance. It is most adaptable to have the boxes of the size of the ordinarily employed wooden containers, or crates. The advantages and economies in transportation consist in the fact that the fruit may be loaded in ordinary box cars, which are much lighter than the ponderous refrigerator cars. They have, moreover, double the capacity of the latter, and the cost of refrigeration is entirely eliminated. If these savings thus brought about are greater than the cost of the process, nothing stands in the way of its practical application from a pecuniary point of view. Cooper has in this manner put up several varieties of fruit, pears, grapes, and cherries, and has achieved good results from the method in each case. After five months even, the fruit was still in an entirely good condition. It was further shown, that in the case of fruit which could not be any longer considered as in a perfectly sound condition, the spoiling made no further progress after it has been packed and treated in these nitrogen containers. After the lapse of a certain length of time they were taken out of the boxes in the same condition in which they had been placed in them. For the transportation of the enormous quantities of fruit from the western part of the United States to the East, this method may therefore very probably be capable of practical application.

As the second new method which has made its appearance, we may mention the preservation by means of high pressure. This also has not yet advanced beyond the experimental stage, and is not yet ripe for introduction in practical industry. Some weighty doubts with regard to the utility of the method must still be dispelled. The behavior of bacteria and yeasts under high pressure had heretofore not been very thoroughly studied, and the method presents itself as something so absolutely new that probably many a man incredulously shook his head when he learned that in this new process heat is left entirely out of consideration. The recognition of bacteria and yeasts as the causes of the putrefaction of eatables was but comparatively slowly and after laborious work brought to general acceptation, and the idea that only certain degrees of temperature—maintained for a definite length of time—lead to their complete destruction, is so firmly and deeply rooted both in theory and practice, that it will naturally be exceedingly hard for the preserve manufacturer to drop the use of the thermometer, upon the observation of which everything heretofore depended, and substitute therefor a heretofore unknown instrument, the manometer. But the facts discovered seem to remove the basis for all doubt.

The results of the experiences heretofore encountered in this new domain have been described in the current volume of the Canner. The investigations were conducted by an experiment station, and the bacteriological investigations connected therewith were carried on in the National Canner's laboratory. The experiments embraced several hundred samples of various fruits and vegetables, which were preserved in glass and tin containers of various size, pint and quart vessels. The pressure varied between 30 and 100,000 pounds to the square inch, and the duration of its application from 30 to 90 minutes. Besides this pressure, absolutely nothing was employed to achieve a good preservability, no chemical preservatives of any kind whatever, and no heat. Among the materials tested were peaches, plums, tomatoes, corn, grape-juice, cider, and huckleberries, and the samples, when opened, were in part three years old and were found then to be entirely sound. Nor were any particular precautionary measures adopted in regard to the selection of the varieties of fruit to be preserved. On the contrary, they were just as they came from the field, generally unpeeled and unwashed. A few experiments, in which yeast and bacteria were intentionally added, in order to test the certainty of the method, appear to be especially valuable. The effect of the high pressure was, that in very many cases, the cell membranes of the germs were burst open.

From the theoretical point of view, the advantage of this method consists in the fact that the pressure is at once distributed throughout the entire mass, and that every particle in the interior of the vessel is immediately subjected to the same pressure as the outermost particles, as the pressure inside of the mass is at once distributed in all directions. This will be obvious to every one who knows how long it sometimes takes before the center of the cans or glasses have reached the temperature necessary for preserving. It is evident, moreover, that a change in the color, a deleterious influence upon either odor or taste, as well as an alteration in the chemical composition, need not be at all feared in the application of this method. In this respect the preserves are practically identical with the fresh food-stuffs. Of course, it is another question whether, through the high pressure applied, the appearance does not suffer, inasmuch as it changes the original form of the food-stuff.

If the preliminary reports are confirmed, and if it will be found possible to construct the necessary machines for practical use, in sufficient power and size, this method probably has a great future before it, and will bring about a complete revolution of the entire preserving industry. At all events, the further development of this method may be viewed with the utmost interest.

The preserving effect of pressure in the preservation of food products has recently become the subject of study in the case of another nutrient, to which a far-reaching application of it in the future has been prophesied. The question is, namely, as to the preservability of milk, which has been carbonized under pressure. It is, of course, known from the brewery, that carbonic acid in itself possesses a certain preserving property, and exercises this effect. It has in recent times, therefore, come into vogue, to impregnate the beer with carbonic acid before it is stored, whereby it was ascertained that the organisms developed with greater difficulty than when the beer is stored uncarbonized. In the case of milk, the same observations were made. Upon the employment of pressure the preserving properties of carbonic acid are emphasized in a heightened degree. Even unpasteurized milk, which was impregnated with carbonic acid under a pressure of 75 to 150 pounds to the square inch, maintained itself in good condition for a long time, and the refreshing, delightful taste of this beverage is extolled on all sides. Experiments under this head have also, among others, been instituted by the experiment stations of the Department of Agriculture of the United States government, and have led to favorable results.

UTILIZATION OF ATMOSPHERIC NITROGEN.

At a meeting of the Faraday Society the paper on the agenda was by Dr. Albert Frank, and referred to the utilization of atmospheric nitrogen in the production of calcium cyanamide and its use in agriculture and chemistry. The author said that however important the new industry was in the production of fertilizers, that was not its only application, as it had been successfully extended to the production from nitrolim of a number of chemical substances by using derivative forms of reaction. Attention had been recently paid to the use of nitrate of guanidine, nitro-guanidine, and dicyandiamide as a deterrent for reducing the temperature of combustion with explosives and gunpowder. The characteristic of dicyandiamide in producing but little heat on decomposition was of great importance in powder used with ordnance, such as cordite and filite. The composition of the crude cyanamide of calcium made it appear likely that it would lend itself for use in casehardening and tempering of iron and steel, and tests had confirmed that view.

The new hardening mixture under the name of ferrodur had been introduced in Germany and other countries; it had the property of producing an extraordinary depth of the hardened surface. Most carbide works obtained at the present time a yield of about two tons of carbide per kilowatt year, and two tons of carbide would combine with practically 500 kilogrammes of nitrogen in the form of nitrolim. Calculation showed that if it were proposed to substitute nitrolim for the nitrate of soda at present consumed it would require plants of no less than 800,000 horse-power. At the end of the present year works for a total production of over 45,000 tons of nitrogen would be in operation, and a large increase in production would be recorded in the near future.

A brief reference to the new works will be of interest. There are at present in Austria-Hungary important cyanamide works in course of erection, all promoted by the Societa Generale of Rome. In Sebenico, in Dalmatia, at the carbide works, one is being built for an initial yearly production of 4,000 tons. At Fiume, in Istria, works are also in construction for a similar output. At the present time a water-power installation of at least 50,000 horse-power is being erected at Almissa, also in Dalmatia, for the manufacture of this new artificial manure. The market for the products of these works will be the Balkans, Asia Minor, and Egypt, where, owing to the practice of irrigation, nitrolim will be of special value to agriculture. In France, the Société Française des Produits Azotes installed works a few months ago at Notre Dame de Briançon (Haute Savoie), for the manufacture of cyanamide, with an output of about 4,000 tons per annum. In the Rhone Valley in Switzerland the Société Suisse des Produits Azotes has just opened equally important works. In Germany the works of Westeregeln and Bruhl on the Rhine are manufacturing 10,000 tons of nitrolim annually. It is interesting to mention that the works at Bruhl for the preparation of carbide do not employ water power, but produce the power required in the work themselves, using cheap coal in large quantities for this purpose. Another installation is that of the Branden-

burgischer Carbidwerke for the preparation of nitrolim with an output of 2,500 tons per annum, near Bromberg, in North Germany, which is also completed, while the large works of the Cyanid Gesellschaft for an output of over 15,000 tons of nitrolim at Alz-Fluss, in Bavaria, are at present in construction. In the United States of North America the American Cyanamide Company has taken up the manufacture of nitrolim, and is constructing on the Canadian side of the Niagara Falls works of a present capacity of from 5,000 to 6,000 tons per annum, to be enlarged later to an output of 40,000 tons.—Page's Weekly.

THE PROCESS OF COAL WASHING.*

DESCRIPTION OF THE APPARATUS EMPLOYED.

BY SAMUEL DIESCHER, SR.

The washing of coal began with the use of coke for smelting purposes, particularly in blast furnaces. In Europe it has been practised about 75 years, because of the large amount of impurities in the coal mined there. Besides volatile matter and carbon, bituminous coal contains ashes and sulphur; both undesirable in the process of iron smelting. The ashes are partly slate and to a smaller extent are in combination with the pure coal. Some of the slate is separate and some attached to coal. It is impracticable to pick all the slate from the coal, as much of it is in too small pieces. The same is true of sulphur in the form of iron pyrites. As both these minerals are detrimental in the production of pig iron, means are necessary to eliminate them from the coal prior to its conversion into coke.

The wet concentration of various ores by means of hand screens was practised centuries ago in European mines. Later the screens were enlarged and mechanically operated. Hence the art was already known when the use of coke in the smelting of iron ores was initiated and it was found that the European coal was not pure enough. The adaptation to coal of the means employed in concentrating ores was only a small step and thus came about the art of coal washing. By crushing the coal, before washing, to sizes not exceeding ¾-inch cubes, the slate and iron pyrites are split off and subsequent washing separates them sufficiently to afford good blast furnace coke.

Sulphur occurs in the coal in combination with lime, as gypsum, which is very difficult to eliminate by the washing process, because it tends to float, and also in combination with organic matter which cannot be removed by any mechanical process. The sulphur occurring as pyrites is largely roasted out in the coke oven, but the other two combinations remain with the coke. Another impurity in coal is what the miners call "bone," which is a combination of earthy matter and bitumen. Some mines contain much, others scarcely any. The nearer its specific gravity is to that of coal, the more difficult it is to wash out.

The more ashes and sulphur in coke the less its market value. With the content in ashes, increases also the quantity of limestone that must be put into the furnace. It takes 2 pounds of limestone for every pound of ashes in the coke, and then again it takes coke to melt that additional limestone. A little limestone must be added also to take up the sulphur in the coke, but still some joins the iron, making it red short.

Fortunately the extensive deposit of pure coking coal in Pennsylvania in the Connellsville region for many years satisfied the demand for coke for blast furnace use. Now, however, it is necessary to draw upon other localities where the coal is suitable after being

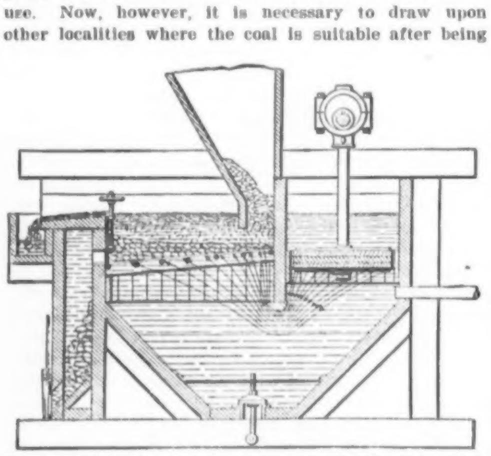


Fig. 1.—THE HARZ JIG AS APPLIED TO THE WASHING OF COAL.

purified. The first attempt in this country to wash coal was made in 1870, when a small washery was erected at Alpsville, about 24 miles from Pittsburg. This plant washed slack from the local mines, and the product was converted into coke at the same place. It was built by a German mining engineer, John J. Endres, who, previously employed at the Prussian government mines, brought drawings and photographs with him and put them to use. During 1871 and 1872 he built several more washing plants; some in connection with so-called "Belgian ovens," that is, retort

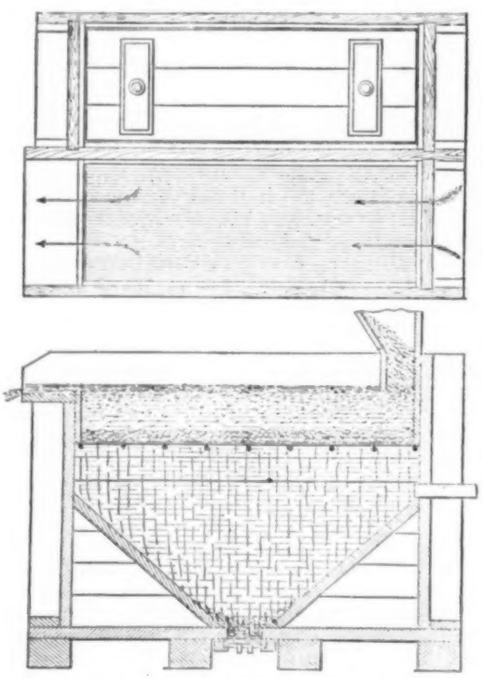


Fig. 3.—PLAN AND SECTIONAL ELEVATION OF A TYPICAL MODERN JIG.

ovens, of the type used for utilizing the by-product from the coking process. These were built at Hazelwood and Hollidaysburg, Pa., Irondale, Ohio, and Equality and Joliet, Ill. A purely washing plant was erected near Mansfield, now called Carnegie, Pa. Soon after the Alpsville plant was put into operation, two companies of St. Louis, Mo., erected extensive washing and coking plants at East St. Louis, Ill. All the plants named have since been dismantled, chiefly because of the panic from 1873 to 1879, when there was no market for washed coke, Connellsville coke being sold at 90 cents a ton at the ovens. During 1879 the iron and coke business renewed, and the price of coke rose from 90 cents to $6 per ton. Consequently, for a couple of years, some demand existed for coal-washing machinery, chiefly by the furnace companies maintaining coke works for supplying their own furnaces. During the last eight years the demand for coke has so increased that washing machines are now being erected at various places.

The washing process is based upon the difference in the specific gravities of the various minerals mixed with the coal as it is mined. These average:

Coal	1.3
Bone	1.4 to 1.8
Slate	2.3 to 2.7
Pyrites	3 to 5

If subjected to the action of a rising current of water the coal rises quickest, the bone next, then the slate, and finally the pyrites.

For many decades ore and quartz were separated in sieves submerged in water and jigged up and down until the quartz, being the lighter, collected on top and the heavy ore settled on the screen. Later on, larger screens were employed and suspended from counterbalanced overhead levers or flexible rods, relieving the operator from holding the sieve. Still later the screens were driven by power. The next step was the invention of the Harz jig, Fig. 1, which originated in the mining region of the Harz Mountains in Germany. Originally it was used exclusively for concentrating ores, but was later adopted also for washing coal. This machine consists of a tank divided into two compartments near the top by a short partition; one contains a screen dipping toward the front, and the other a wooden piston operated by an eccentric. The front of the screen compartment is cut down below the other sides and provided with a shelf for the overflow to run out over. The water enters the tank through a pipe in the rear, below the piston.

The operation of the machine is as follows: After the tank is filled to overflowing the supply of water is continued and coal is admitted through the hopper at the rear of the screen. With every down stroke of the piston the water rises through the screen and lifts the coal and its impurities, gradually spreading them over the screen until the space above is filled even with the overflow line. From then on, the washed coal is carried over the shelf by the current. While the material travels from the rear toward the front, the whole mass is lifted and dropped many times; with every upward movement the lighter bodies rise quicker and higher, and with every downward movement the heavier particles sink faster and lower, separating the materials in horizontal layers according to their specific gravities. The pyrites, being the heaviest, will lie directly upon the screen, the slate above it and the coal above the slate.

In Fig. 1 will be seen a gate attached to the inner side of the front of the screen compartment for discharging the refuse at periods of 5 to 15 minutes, depending upon the proportion of refuse in the coal. The refuse drops into the narrow compartment in the front below the overflow shelf, which holds approximately half an hour's accumulation, and is periodically emptied through another gate at the bottom. There is also a valve in the bottom of the tank, through which any fine material which drops through the screen is from time to time discharged.

It is obvious that opening of the refuse gate must be properly timed. If too infrequent the refuse may accumulate until it passes over with the washed coal; if too frequent coal is discharged with the refuse. The close attention required from the operator prevents his taking charge of more than four jigs. Some modern washeries have 20 or more jigs, necessitating five or more men to attend them. To provide an automatic continuous discharge for the refuse, the Harz jig was variously modified. It was supposed that the reciprocating piston would oscillate the water in the tank uniformly, but the main body of water remains at rest and only that part displaced by the piston and supplied through the pipe is set in motion. This water chooses the shortest course, which is around the lower edge of the partition; therefore most of it passes through the rear half of the screen, near the coal chute. Proper washing requires uniform action of the

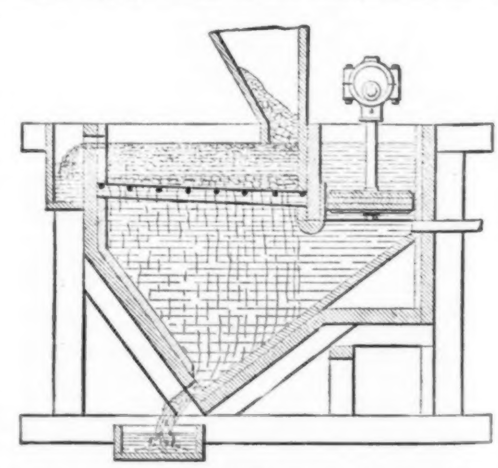


Fig. 2.—LÜHRIG'S ATTEMPT TO IMPROVE THE HARZ JIG.

water all over the screen. Too strong a current at the rear will not separate, but only agitate the material, and too weak a one at the front end does no work; there remains only a comparatively small section about the middle of the screen over which the work is properly done. This condition is aggravated by the further obstruction of uniform rise of the water due to the greater depth of the charge at the front and the

* Abstract of a paper read before the Engineers' Society of Western Pennsylvania.

accumulation of heavy refuse there. In short, the force of the current is greatest where the load is least, and least where the load is greatest.

Lührig undertook to remedy the evil by inclining the screen toward the rear, as in Fig. 2, so that the greatest depth and heaviest load came where the current is strongest. This would have been very good had a slate trap been located there, because the refuse travels toward that point, but instead he used a bed of feldspar all over the screen, made the holes in the latter large, and let the refuse drop through into the chamber below, to be removed by a continuous drain from the machine. On such machines all sizes of coal, up to above ¾-inch mesh, were washed. The holes in the plates which formed the screen were 1 inch square, and the feldspar the size of walnuts. On account of the large holes and the coarseness of the feldspar a considerable quantity of coal dust goes with the refuse. An establishment using 16 of these jigs has three additional jigs for washing the refuse to save the coal it contains. There is also Lührig's jig intended for washing coarse coal, which is the same as the Harz jig; that is, its screen inclines toward the front and it has slate grates there and uses no feldspar.

Fig. 3 gives a sectional elevation and plan of a typical modern jig. The characteristic feature is that the screen is narrow and long; it is never over 24 inches wide, but may be as much as 6 feet long. The piston is of the same dimensions as the screen and is parallel with it. This jig may be used with or without a feldspar bed, in which latter case the refuse is removed at the overflow end of the screen. In either case the screen is level. If feldspar is used, the refuse drops through holes in the screen. Feldspar is advantageous chiefly in washing material from a ¼-inch mesh downward, including dust. If used for larger sized coal the refuse must be washed to save the coal that drops through the screen.

The most rational way to obtain uniform action of the current is to locate the piston directly below the screen and make it practically of the same dimensions as the latter. Fig. 4 gives a front elevation, plan, and end section of such a machine. With this construction the screen may be of any size and shape and yet work uniformly as long as the piston is of approximately the screen's dimensions. This machine may be built with or without valves in its plunger. Without valves the water displaced by the down stroke of the piston passes into a secondary compartment and returns again with the rise of the piston. If there are two jigs in one tank the pistons work in opposition, one rising while the other descends, thus the water displaced by one fills the space vacated by the other. If the piston has valves, the water supply for a group of two or four jigs within one large tank is all led into a common compartment from which each jig draws its supply. The valves are either of steel plate or thin iron castings.

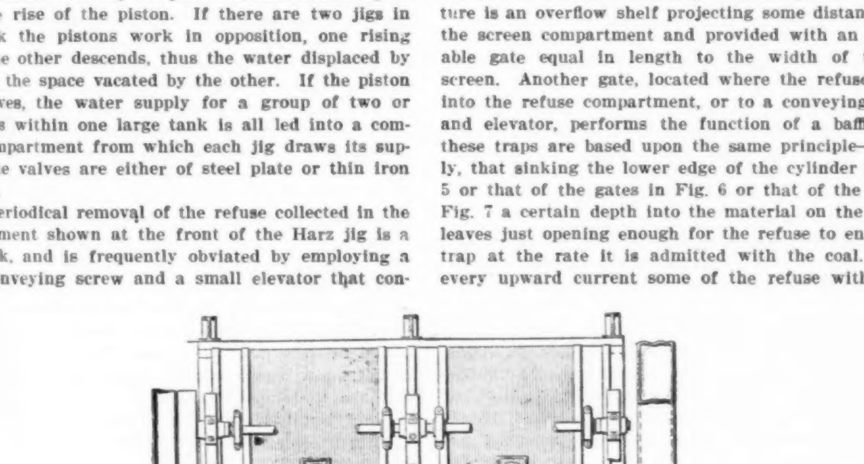


Fig. 4.—PLAN, FRONT ELEVATION, AND END SECTION OF A DOUBLE JIG GIVING UNIFORM ACTION.

The periodical removal of the refuse collected in the compartment shown at the front of the Harz jig is a drawback, and is frequently obviated by employing a short conveying screw and a small elevator that continuously removes the refuse at the rate at which it is produced. One of the oldest devices for continuous and automatic refuse removal is shown in Fig. 5. It consists of an iron pipe, usually about 3 inches in diameter, that projects upward through the jig screen about 2 inches, depending upon the size and average specific gravity of the refuse. It is adjustable through a threaded socket secured in the center of the screen, and is surrounded by a sheet-iron cylinder, open at top and bottom, which is considerably larger in diameter and higher than the pipe, and is also adjustable in height to insure its greatest efficiency. As seen in Fig. 5, the adjusting is by screws and nuts which suspend the cylinder from an iron bar laid across the screen compartment of the jig. The passage of the refuse between the lower edge of the cylinder and the surface of the screen is regulated according to the quantity to be discharged through the central pipe in a given time. The refuse drops into the space below the screen, whence it is removed either periodically or continuously in one or the other manner referred to before. With every upward current the refuse within the cylinder rises above the top edge of the pipe and as the particles toss each other laterally, a portion enters the pipe and is thus removed. This device is good for washing ore where the bulk treated is small compared with the quantities of coal that must go through a jig during a given time; for this reason it is not used much in the coal washing process.

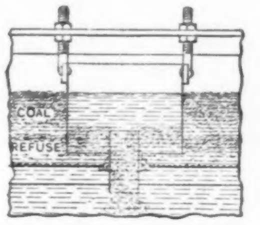


Fig. 5.

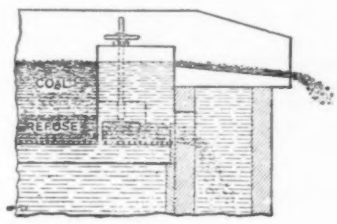


Fig. 6.

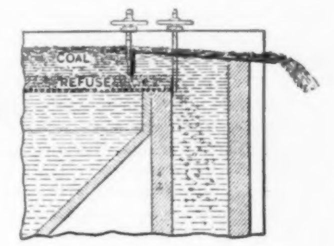


Fig. 7.

DETAILS OF THREE DIFFERENT SCHEMES FOR EFFECTING AUTOMATIC CONTINUOU REFUSE REMOVAL.

Another device better adapted for coal is shown in Fig. 6. This is an oblong box, open at the top and bottom and provided with vertical sliding gates, about 5 or 6 inches wide, which are raised by the operator sufficiently to admit the refuse as fast as it is brought upon the screen with the coal. An iron baffle at the opening in the front plank accumulates the refuse until even with its upper edge, the additional refuse being discharged with every revolution of the eccentric shaft.

Fig. 7 is a section of a trap with two gates. Its feature is an overflow shelf projecting some distance into the screen compartment and provided with an adjustable gate equal in length to the width of the jig screen. Another gate, located where the refuse drops into the refuse compartment, or to a conveying screw and elevator, performs the function of a baffle. All these traps are based upon the same principle—namely, that sinking the lower edge of the cylinder in Fig. 5 or that of the gates in Fig. 6 or that of the cup in Fig. 7 a certain depth into the material on the screen leaves just opening enough for the refuse to enter the trap at the rate it is admitted with the coal. With every upward current some of the refuse within the trap moves into the collecting chamber, or elevator, leaving insufficient to resist the lateral pressure exerted by the outer material, and thus while the latter sinks with the downward current, as much refuse will enter as has been discharged at the preceding rise of the material.

The device in the jig shown in Fig. 4 is larger than usual, because it is on a very large screen where a coarser and accordingly larger amount of coal is treated during a given time. For this reason the box is extended beyond the middle of the screen, because the coarsest and heaviest refuse drops earliest, and to forestall a detrimental accumulation of this heavy stuff a large gate is provided at that particular point of the machine.

A well-working jig will wash about 4 tons of Pittsburg coal per square foot of jig screen in 10 hours. The process is slower the more bone the coal contains, and the finer the coal must be crushed to separate the impurities preparatory to washing. It is an advantage to crush all coal to a certain maximum size, as, for example, to pass a ½, ⅝, or ¾-inch mesh. If there is no provision made for washing the fine coal, from ¼-inch mesh down, in separate machines, it may be washed together with ½-inch or even larger coal, but only on a level screen; otherwise much of the fine coal is sucked through the screen whenever the current passes backward. A slanting jig screen, unlike a level screen, always has its highest part exposed, or uncovered by refuse. To save the fine coal that drops through the screen is not advisable, because much sulphur and fine slate is mixed with it and would impair the purity of the coke if saved.

The first washeries built in this country were very simple compared with the large modern plants established at some of the coke works in Westmoreland County, Pennsylvania, and elsewhere. Provisions for collecting and saving sludge add greatly to the cost and complication of such plants, as does also the present tendency to place heavy machinery in the third or fourth story of a wooden building. Matters can be very much simplified by washing the fine coal separate from the coarser coal, and passing it over slanting draining screens, directly as it leaves the jigs. This does away with the expensive and trouble-breeding sludge basins. The water can be used over after passing through a comparatively small settling tank having means for continuously removing sediment. In this case the coarse coal would be conducted directly into the elevator booth, and the water would flow back to the centrifugal circulating pumps, to be used over again.

The quantity of water used in washing coal is, if none is wasted and none used over, approximately 1½ gallons per minute for every ton of coal washed in 10 hours. Where water is scarce and must be used repeatedly, the continuous supply required is from 10 to 20 per cent of the above amount. Water for washing coal should be renewed as often as conditions permit, for more or less sulphur and fine refuse is always suspended in it which is bound to affect the quality of the product. A great variety of conditions contingent to different localities have their influence upon the cost of construction of coal washing plants. Approximately a plant will cost from $35 to $50 for every ton of its washing capacity in 10 hours. Thus a plant washing 500 tons in 10 hours, at say $45 per ton, will cost $22,500.

Mr. T. U. Walton, of Sydney, has published an account of a remarkable deposit found in the brass tubes of a small locomotive that had been working for some time. It was in the form of a dense black scale, thicker than the walls of the tubes, and similar to gas-black in appearance. On analysis, it was found to consist of 88.89 per cent of fixed carbon, 2.98 per cent of volatile hydrocarbons, and 8.13 per cent of ash. As the ash in the coal used was about 4 per cent higher than that of the deposit, coal dust could only have been the source of part of the deposit, the remainder probably consisting of gas carbon derived from the condensed hydrocarbons. A considerable loss of heat would probably result from this coating of the tubes with a thick layer of a material of low heat-conductive power. In experiments made in the University of Illinois, by Messrs. Schmidt and Snodgrass, it was found that the loss of heat with a scale ⅛ inch thick was from 10 to 12 per cent, or considerably less than was anticipated. A further conclusion arrived at was that the structure of the deposit had far more influence than the thickness upon the loss of heat, and that the chemical composition was only of importance in this respect in so far as it influenced the structure.

WOOD PRESERVATION.*

THE MEANING OF DECAY AND HOW IT MAY BE CHECKED.

BY W. F. SHERFESEE.

It is easy to see that if the length of time timbers can be used is doubled, only half as much timber will be required as before and only one-half as much money will need to be spent in the purchase of timber. This is the chief gain in treating wood with preservatives. Yet there is another and important one. Many woods, which for a long time were considered almost worthless, can be treated and made to last as long as the scarcer and more expensive kinds. This of course means that the consumer will have the choice of a much greater number of woods than he had before and at less cost.

Wood preservation, then, prolongs the life of timbers in use, reduces their cost, and gives to the user a wider choice of woods than ever before.

Methods of preservation must be varied for different localities and different kinds of wood.

WHAT DECAY IS.

The decay of a plant body, such as wood, is not an inorganic process like the rusting of iron or the crumbling of stone, but is due to the activities of low forms of plant life called bacteria and fungi. Bacteria are among the simplest of all forms of life, often consisting of but a single cell, microscopic in size. Sometimes several such cells may be attached to each other, and so form a thread or filament. Usually they are colorless, and multiply by the division of the parent cell into other cells, which, in turn, divide again.

Fungi, although much more complicated than bacteria, are also low in the scale of creation when compared with familiar flowering plants and shrubs. They consist merely of tiny threads or hyphæ, which are collectively known as the mycelium. In many of the higher forms of fungi the threads grow together to form compact masses of tissue. Familiar examples of these forms are the toadstools which grow on damp, rotting logs, and the "punks," or "brackets," on the trunks of trees in the forest.

The causes of decay in wood, however, are not these fruiting bodies themselves. Spores, very primitive substitutes for seed, which are borne in the countless compartments into which the under surfaces of the fruiting bodies are sometimes divided, are produced in infinite number, and are so fine that they can be distinguished only by the microscope. When seen in bulk they appear as the finest dust. Like dust, they are carried by the wind and strike all portions of the surrounding objects. Few species of fungi successfully attack healthy living trees, and only a comparatively small number can attack and destroy wood. Yet the spores of some find a lodging in dead portions of a tree or in cut timber, and, if the wood is moist and in the right condition for the spore to grow, it germinates and sends out a thin, filmlike white thread, which, by repeated branching, penetrates the entire structure of the wood. These are the real agents of decay.

This is not the only way that a fungus can enter a sound stick of timber; for if a good stick is lying close to a rotting one, the mycelium may grow over or through the moist ground and so reach the sound stick, which it immediately attacks. Sometimes, too, when a tree is cut it already has a fungus growing in its wood. If the fungus happens to be a true parasite —that is, if it can grow only in living tissues—it will die when the tree is felled; but if it has been accustomed to growing in the heartwood of the tree, which is practically dead, it may continue to live and develop even after the tree has been sawed into timber.

Wood is composed of minute cells. The chief material of the cell-walls is a substance called cellulose, and around this there are incrusted many different organic substances known collectively as lignin. Most of the wood-destroying fungi attack only the lignin; others attack the cellulose alone, while a third class destroy all parts of the wood structure. The lignin and the cellulose are dissolved by certain substances secreted in the fungi, and thus serve as food for the fungus growth. In this way the fungi can develop until they extend throughout every portion of the timber. After a time the amount of fiber changed into food and assimilated by the fungus causes the wood to become discolored. Discoloration may also be produced by pigments in the fungus or secreted by it. Finally so much of the wood fiber is eaten away or changed in composition that its strength is greatly diminished, the texture becomes brittle and disconnected, and the wood is said to be "rotten."

But food is not the only thing that a fungus requires for its growth and development. It must also have heat, air, and moisture. If any one of these is lacking the fungus cannot develop. The necessary heat is supplied by almost every climate, and it is only in rare cases, as under water or deep under the surface of the ground, that air can be excluded from the timber. Of the four requirements, therefore, two are beyond control. It is only by depriving the fungi of food or moisture that the destruction they cause can be prevented.

HOW DECAY CAN BE RETARDED.

By Seasoning.—The simplest way of prolonging the life of timber exposed to the attack of wood-destroying fungi is to reduce the moisture content of the wood. The amount of water in green timber varies according to the part of the tree from which the wood is cut. The outer layers of the trunk are composed of sapwood, the cells of which contain large amounts of organic substances which serve excellently as food for the fungi. Moreover, sapwood always contains a large amount of water. It is the portion of the tree, therefore, most susceptible to attacks from fungi. Heartwood, which can usually be distinguished from sapwood by its darker or more reddish color, contains, on the other hand, much less moisture. It is therefore more durable than sapwood. But because its pores are stopped up by germs and resins it dries out much less rapidly than the more porous sapwood. In almost every case as much care should be taken thoroughly to dry out the heartwood as in the case of the moister sapwood.

By piling the timber so as to permit free access of air all around it the moisture content of timbers of certain sizes can be reduced to about 15 or 18 per cent. Of course the climate has a great influence on the rate at which the wood dries out and the total amount of moisture it loses.

The moisture content of air-dry wood can be still further reduced by kiln-drying; and this is employed to a considerable extent, but usually for other purposes than increasing the durability of the wood. Moreover, either air-dry or kiln-dry wood has the power to reabsorb moisture when exposed to the atmosphere in damp situations, and so the benefits of drying, as far as durability is concerned, are only moderate. Yet the increased life which it gives is, in nearly all cases, more than sufficient to repay the added cost of seasoning.

The strength of partially seasoned timber, other things being equal, increases as the amount of moisture it contains decreases. Thoroughly seasoned timber of small sizes is sometimes three or even four times as strong as the same timber, when green. Moreover, during the process of drying out, important but little understood changes take place in the organic contents of the wood cells, by which the wood is not only rendered less attractive to fungi, but is made more permeable and so better prepared for preservative treatment. All timber should be thoroughly seasoned before being exposed to decay.

An exterior coating secured by dipping a post in a thin solution of cement or other material that will harden on the post is not an effective protection, because in shrinking or swelling the wood forms cracks through which decay enters.

By Chemical Impregnation.—By far the best method of checking the growth of fungi, however, is to deprive them of food. This can be done by injecting poisonous substances into the timber, and so changing the organic matter from foods suitable for fungi into powerful fungicides. It is a mistake to suppose that the germs of decay are inherent in the wood, and only need an opportunity for development to bring about its destruction. Several processes for the preservation of wood have been founded on the false assumption that it is necessary to destroy the "germs" in the interior of the timber. The impression doubtless arose from the fact that, after a stick of timber begins to rot, it is impossible to tell just where the fungus spores germinated and gained entrance into the timber. Moreover, the fact that the interior of the wood may have reached an advanced stage of decay before there are any external evidences of the fungi—such as fruiting bodies, or films of mycelium—tends to convince the casual observer that decay starts from the interior. Yet the wood destroying agencies start from the outside. This explains the efficacy of certain paints which merely form a superficial coating over the surface of the timber, but which are poisonous enough to prevent the spores from germinating, or the hyphæ of most forms of wood-destroying fungi from penetrating into the unprotected wood in the interior. The ancients were in the habit of painting their statues with oily and bituminous preparations to preserve them from decay. The great wooden statue of Diana at Ephesus, which was supposed to have descended miraculously from heaven, was protected from earthly decay by oil of nard. Pettigrew extracted the preservative fluids from the heart of an Egyptian mummy that had resisted decay for over 3,000 years, and found that decomposition immediately set in. This showed that it was the presence of the antiseptics which prevented decay, and not a chemical change of the tissues.

PRESERVATIVES AND PROCESSES IN THE UNITED STATES.

Of the many antiseptics which have been proposed for the preservation of timber only four have been largely used with success in the United States. These are creosote, zinc chlorid, corrosive sublimate (bichlorid of mercury), and copper sulphate. At the present time copper sulphate has fallen into almost total disuse, and corrosive sublimate is restricted to two plants in New England. The use of this latter is the so-called "kyanizing" process which is so frequently referred to in all the literature of wood preservation. In general, the process consists in steeping the timber in a dilute solution of corrosive sublimate long enough to insure thorough penetration.

Creosote and Zinc Chlorid.—Thus in the United States creosote and zinc chlorid are the only preservatives in common use. There are many other patented substances known by various names; but most of them have for their base one or the other of these two preservatives. Creosote is a by-product of coal tar, which is produced at most plants for the manufacture of illuminating gas and at by-product coke-oven plants. This tar is distilled, and during the process the condensed vapors are run into three separate vessels and thus separated into the light oils of coal tar or naphthas, the dead oil of coal tar or creosote, and pitch. Creosote is not a simple substance like zinc chlorid. On the contrary, it contains a large number of constituents of great chemical complexity.

Wood tar, when distilled in a similar manner, gives "wood creosote," which like that derived from coal tar, possesses strong antiseptic properties. There is also on the market a so-called creosote, a by-product of water-gas tar or tar manufactured from kerosene oils, which for wood preservation is probably inferior to the true creosote. In general, however, by "creosote" is meant the dead oil of coal tar.

Zinc chlorid is obtained by dissolving metallic zinc in hydrochloric acid. This is further diluted by water before it is used for wood preservation.

Just as there are two preservatives in common use, so there are two principal methods of injecting them into the timber. These may be called the "pressure-cylinder method" and the "open-tank method." A third process, known as the "brush method," is used to a more limited extent.

The Pressure Processes.—Up to very recent times the pressure-cylinder method was used almost exclusively in the United States. With creosote it is known as the Bethell process, and with zinc chlorid the name of Burnettizing is applied. The timber to be treated is placed on iron trucks or "cylinder buggies" and drawn by steel cables into huge horizontal cylinders, some of which are 8 or even 9 feet in diameter and more than 150 feet long. These are capable of withstanding high pressure, and their doors are so arranged that, after the timber is drawn in, they can be closed and hermetically sealed. It is the common practice in this country—a practice which long experience in Europe, as well as in America, has proved to be unwise—to treat the timber before it has had time to dry out in the open air. The following is the usual method. After the doors are closed live steam is admitted into the cylinder, and a pressure of about 20 pounds per square inch is maintained for several hours, the exact time depending upon the individual opinion of the operator, as well as upon the moisture content and size of the timber under treatment. In some cases the steam pressure is allowed to go considerably above 20 pounds, but there is constant risk of injuring the strength of the timber. When the steam is at last blown out of the cylinder, the vacuum pumps are started and as much of the air as possible is exhausted from the cylinder and from the wood structure. This process also continues for several hours. Finally, after the completion of the vacuum period, the preservative is run into the cylinder and the pressure pumps are started and continued until

* Abstracted from a Forest Service circular published by the United States Department of Agriculture.

the desired amount of preservative fluid is forced into the wood. The surplus preservative is then blown back into the storage tanks, the timber is allowed to drip for a few minutes, and finally the cylinder doors are opened and the treated timber is withdrawn.

The Open-tank Process.—The injection of the preservative by the open-tank process depends upon a different principle. The wood is first thoroughly seasoned, and much of the moisture in the cells and intercellular spaces is replaced by air. If the timber is peeled soon after cutting, and stacked in open piles, the time required for seasoning can be greatly lessened. The seasoned timber, or that portion of it which is to be preserved, is immersed in a hot bath of the preservative contained in an open iron tank. This hot bath is continued for from one to five or six hours, depending upon the timber. During this portion of the treatment the air and moisture in the wood expand and a portion of them pass out, appearing as little bubbles on the surface of the fluid. At the end of the hot bath, as quick a change as possible is made from the hot to a cold preservative. This causes a contraction of the air and moisture remaining in the wood, and, since a portion of it had been expelled, a partial vacuum is created which can be destroyed only by the entrance of the preservative. Thus atmospheric pressure accomplishes that for which artificial pressure is needed in most of the commercial plants. Whether the open-tank or pressure-cylinder method is the more desirable depends upon the particular conditions of each case. Both methods have their particular uses and neither can always be wholly substituted for the other.

The Brush Method.—A less efficient but cheaper treatment can be secured by painting the surface of the timber with at least two coats of hot creosote or some similar preservative. The liquid may be applied with an ordinary brush, but care should be taken to fill thoroughly with the preservative all checks, knot holes, and similar defects. The liquid can penetrate only a very short distance into the wood, but as long as there remains an unbroken antiseptic zone around the surface, the spores of the wood-destroying fungi cannot enter. It is especially important in this method that the timber should be thoroughly air-dry before treatment. Otherwise the evaporation of water from the interior of the stick will cause checks to open up and so expose the unprotected wood to fungous attack.

This process finds its principal use where the amount of timber to be treated is too small to justify the erection of even a small treating plant; where the land is so rugged, as in the building of mountain telephone lines, that it is impracticable to transport the timber for even short distances, or where it is necessary to restrict the cost of the treatment to the lowest possible figure.

The Effect of Treatment on the Strength of Timber. —The question is frequently asked whether or not the strength of timber is impaired by the processes in common use for wood preservation. No general answer to this can be given, since it depends altogether upon the character and strength of the preservative and the care with which it is injected. It is probable that creosote does not penetrate the wood fibers, but merely forms an external coating around them; hence, in itself, it can not appreciably affect the strength of the timber. In general the ultimate strength of treated timber depends, first, upon the percentage of moisture remaining in the wood; and, second, upon whether or not the wood has been subjected to injuriously high temperatures during the preliminary processes of steaming and vacuum, if these processes were employed. The degree of temperature which can be applied without risk of serious injury depends upon the duration of the temperature, the moisture content and quality of the wood, and upon the pressure to which it is subjected.

If proper care is observed in the treatment of the timber all danger of injury from excessive temperatures can be avoided. The amount of moisture remaining in the wood is therefore a point of greater importance. As the moisture in a piece of wood is reduced by drying, the strength of the wood increases, and as moisture is subsequently reabsorbed, the strength up to a certain limit is again reduced. Creosote retards both the absorption and evaporation of water; hence its presence in thoroughly seasoned wood exposed to humid conditions tends to conserve its strength, whereas, on the other hand, if it is applied to green wood the strengthening action of water-evaporation is retarded. Some processes tend to increase the moisture content of the wood and others diminish it. Therefore, whether the strength of timber is increased or decreased during creosoting depends chiefly upon the process employed.

The effect which live steam at safe temperatures has upon the moisture content of wood is now being made the subject of a special study. It is safe to say, however, that during steaming the amount of moisture in air-dry timber is increased, with a consequent decrease in strength, and that the succeeding vacuum fails to remove all of the added moisture before the introduction of the preservative. With many kinds of air-dry timber, however, the steaming can be dispensed with altogether, and this is done in many commercial plants. Whether or not it can be omitted with all kinds of wood is not yet certain.

These considerations, of course, do not apply to the open-tank method, or to similar processes where the timber is immersed directly in the hot preservative, without the preliminary steaming and vacuum. Immersion in hot oil tends to evaporate some of the moisture in the wood and so to increase the strength.

Zinc chlorid and the other preservatives which are in water solution have a wholly different effect. Unless the wood structure is already filled with moisture to the point of saturation, more water is injected into it with the preservative, with the result, if the wood is partially seasoned, of decreasing its strength. The original strength may be regained, however, by seasoning. If the zinc chlorid is injected into the timber in too concentrated a solution it may cause a chemical dissolution of portions of the wood fiber, with the result of permanently decreasing the strength of the timber. But for the solutions in common use this danger need not be taken into consideration.

Both creosote and zinc chlorid are excellent antiseptics, and both can be obtained in large quantities. Creosote's principal point of superiority, however, lies in its insolubility in water. Hence, once it is injected into timber it will not wash out, no matter how wet may be the situation in which the treated timber is placed. On the other hand, zinc chlorid is much cheaper than creosote, and since it is shipped in the form of a solid the freight charges are considerably less than they would be for enough creosote to treat the same amount of timber. But zinc chlorid is soluble in water, being in fact injected into the timber in water solution, and so when timber treated with zinc chlorid is exposed to moisture the leaching out of the salt is only a question of time. Hence, zinc chlorid is most commonly used in comparatively dry situations. Creosote, on the other hand, is used where the timber will be subjected to moisture. Moreover, creosote is one of the very few preservatives within commercial reach which offer absolute protection against the marine borers, which work such havoc among the wharves of the Atlantic, Gulf, and Pacific coasts. Since it is insoluble in water it can not wash out of the piles into which it has been properly injected, and since it is more than a mere external coating there is no danger of its being broken off by floating débris.

THE TENDENCY OF WOOD PRESERVATION IN THE UNITED STATES.

In the United States the tendency in wood preservation is to modify the processes rather than to change the preservatives. At present, creosote and zinc chlorid, pure or in mixture, are the only preservatives which are in general use. A constant effort is being made to overcome the chief drawbacks to the use of each of these. Processes have been developed which involve the compression and expansion of the air in the wood structure to expel some of the expensive creosote, leaving only a film along the cell walls. The amount of oil left in the timber is reduced, and in consequence the cost of the treatment as well. In other cases zinc chlorid and creosote are mixed together and injected into the timber in the form of an emulsion, the object being to reduce the cost of the treatment and to prevent the zinc chlorid from leaching out of the timber. Sometimes the timber is impregnated with zinc chlorid, and only a narrow outer layer is filled with creosote; or again, glue and tannin are employed in the effort to plug up the outer wood cells and so keep the salt in the interior.

THE SAVING IN DOLLARS AND CENTS.

No process to preserve timber can come into use unless it is certain that the outlay for the treatment will be more than offset by the longer service of the treated timber. It is difficult to give a general example of the saving effected by treating certain timbers with preservatives, since it depends so largely upon local conditions and the class of timber. The following examples of the saving which under certain circumstances can be effected by proper preservative treatment are, however, typical, although they may not apply to other localities and to other kinds of timber without some modification:

An untreated loblolly pine fence post costs about 8 cents, or, including the cost of setting, 14 cents. Its length of life in this condition is about two years. Compounding interest at 5 per cent, the annual charge on such a post is 7.53 cents—that is, it costs 7.53 cents a year to keep such a post in service. If given a preservative treatment, which costs about 10 cents, the length of life of the post is increased to about eighteen years. The total cost of such a post, set, is then 24 cents, which, compounded at the above interest rate, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

The saving due to treating railroad ties is also worthy of consideration. A loblolly pine tie untreated is worth about 30 cents, and its length of life in this condition is about five years. To this first cost should be added the cost of laying, which is about 20 cents. The annual charge figured as above is then 11.52 cents. If treated it will last for about twelve years. Its cost of treatment is about 35 cents. A treated tie in the track, therefore, costs about 85 cents. Compounded at 5 per cent, as in the above example, its annual charge is 9.48 cents. The saving per year is therefore 2.04 cents per tie. Assuming 2,880 ties per mile of track, the saving due to treatment alone amounts to $58.75 per mile, which corresponds to an investment of $1,175 per mile.

Assuming that the cost of an untreated oldfield or loblolly pine pole, including hauling and setting, is $5, and that it lasts five years—a fair estimate for many portions of the United States—the annual charge, compounding interest at 5 per cent, amounts to $1.15. In other words, it costs the owner $1.15 a year for every such pole in his lines. This corresponds to a capital of $23 invested at 5 per cent interest, or, for a mile of 40 poles, to $920. Again, assuming that the butt of such a pole can be treated for $1, the first cost of the pole, set in the ground, is $6. The treatment may reasonably be expected to secure a service from the pole of twenty years, instead of five years when untreated. Thus, the annual charge on the treated pole, with the same rate of compound interest, is only $0.48 per pole, which corresponds to an investment of $9.60; or $384 per mile, as compared with $920 per mile in the other case. Thus during the life of the treated pole a yearly saving of the interest on $536 will be effected for every mile of line.

It might be said that it is not positively proved that the treated poles will last twenty years, and that it will be necessary to wait until the poles are finally removed before the length of their service can be determined. A sufficient answer to this argument is that treated poles need to last only 1.6 years longer than untreated poles in order to justify the cost of treatment. Moreover, there is abundant evidence to show the long life of creosoted wood. Even in this country there are many examples of poles and other timbers creosoted twenty and even thirty years ago, which to-day are apparently as sound as when first set in the ground. In Europe, where wood preservation is an older industry, the results are still more marked. There have been failures, but in every instance they can be traced to incompetent or fraudulent work, insufficient impregnation, improper preparation of the timber, or some similar cause.

WHAT WOOD PRESERVATION CAN DO IN THE FUTURE.

At the present rate of consumption the exhaustion of the supply of structural timbers in the United States is a thing of the very near future. Moreover, the cost of fence posts is an ever-increasing burden upon the farmer and stockman. In the case of structural timbers telephone poles will serve as an example. Statistics gathered by the Forest Service show that in 1906 more than 3,500,000 telephone and telegraph poles were cut. This includes only poles 20 feet and over in length, and ignores the far greater number of poles and posts of smaller sizes. Of the poles cut, at least 40 per cent, or nearly 1,500,000, were either of white cedar or of arborvitæ.

Under average forest conditions it requires more than one hundred and ninety years to grow a 30-foot cedar pole. The average life of such a pole, when set in the ground in its natural state, does not exceed fifteen years. In other words, in order to meet even the present annual consumption there must be nearly thirteen trees growing in the forest for every 30-foot cedar pole standing to-day. A study of the rates of growth and the durability of other kinds of wood used for other purposes—ties, mine props, piling, etc.—shows that the consumption of structural timber greatly exceeds its production. Yet relief can be had in prolonging the length of service of the timber now being placed in position. Most of the cross-ties placed in the track to-day must be renewed within eight years. But if their life can be lengthened to fifteen years the benefits of the preservative treatments are plain. It is estimated that 150,000 acres are required each year to grow timber for the anthracite coal mines alone. The average life of an untreated mine prop is not more than three years. By proper preservative treatment it can be prolonged by many times this figure. Poles which in ten or twelve years, or even less, decay so badly at the ground line that they have to be removed can, by a simple treatment of their butts, be made to last twenty or twenty-five years. The same is true of fence posts and other timbers exposed to direct contact with the soil. Sap shingles, which are almost valueless in their natural state, can be easily treated and made to outlast even painted shingles of the most decay-resistant woods. Thousands of dollars are lost every year by the so-called "bluing" of freshly sawed sapwood lumber. This can often be prevented by proper treatment and at a cost so small as to put the method within the reach of the smallest

operator. Millions of feet of insect and fire-killed timber in the West are standing untouched in the forest. Under present conditions this timber is not only useless, but is an actual detriment to the forest. Much of this dead wood possesses all the requirements of high-grade structural timber, with the single exception of durability. Often where dead timber is most abundant there is an almost complete absence of the naturally durable kinds of wood, and timber for structural purposes—ties, mine timbers, poles, posts, etc.—must be transported long distances at heavy expense. The thorough seasoning of several years has strengthened the dead wood and put it in an excellent condition for treatment. Fortunately, most of it is of a kind which readily absorbs the liquid preservatives, and so is well adapted to successful impregnation. Therefore, expensive pressure plants are, in most cases, unnecessary, and the cost of erecting and operating a small open-tank treating plant is surprisingly low. In the South the cheap and abundant loblolly pine, one of the easiest of all woods to treat, can by proper preparation be made to take the place of the high-grade long-leaf pine for many purposes. Black and tupelo gums and other little-used woods have a new and increasing importance because of the possibility of preserving them from decay at small cost. In the Northwestern and Lake States are tamarack, hemlock, beech, birch, and maple, and the red and black oaks, all of which by proper treatment may help to replace the fast-diminishing white oak and cedar. In the States of the Mississippi Valley the pressing fence-post problem may be greatly relieved by treating such species as cottonwood, willow, and elm.

SCIENCE NOTES.

Platinum, which sold at $40 an ounce a year ago, has taken a big decline, and is now quoted at just half as much, $20 an ounce. The price of platinum doubled between 1905 and 1907, and is now back to the 1905 price. It sold as low as $8 to $10 an ounce fifteen years ago.

It is in general possible to determine the concentration of the solution of an organic substance in an organic solvent more rapidly by an observation of the refraction index than by the density. Launcelot Andrews states that this is eminently so when the observation is made by the Zeiss immersion refractometer, which is frequently possible when the solvent is ether, alcohol, or especially methyl alcohol.

A powerful fish poison used by the natives of the Ivory Coast is prepared from the fruit of the plant, *Strychnos aculeata*, the active principle of which is so toxic that the addition of one part of the fruit to 10,000 parts of water will kill any fish that may be present. In small doses, however, the poison has no effect upon mammals or frogs. An examination of the fruit has been made by M. A. Hébert, who, contrary to expectation, found it to be quite free from strychnine, and to contain only a trace of brucine, the amount in the kernels, which contained the most, not exceeding 0.05 per cent. A substance, probably a glucoside, was isolated, which was found to have the characteristic toxic action upon fish.

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TRADE NOTES AND FORMULÆ.

To Stick Cloth or Leather to Table Tops.—Two and a quarter pounds of wheat flour, 4 tablespoonfuls of powdered rosin, and 2 tablespoonfuls of powdered alum; heat and mix to a stiff consistency.

Artificial Wood Mass for Picture Frames.—Melt 10 parts of glue in water and stir in 4 parts of ground litharge, 8 parts of white lead, 10 parts of fine sawdust, and 1 part of gypsum. The finished mixture must be poured into two-part molds, well oiled, taken out after hardening, and painted, gilded, bronzed, etc.

Preservation of Roasting Coffee (Liebig's method).—After roasting, while still hot, sprinkle over it pulverized sugar, stir it in well, sprinkle on some more and then put it up for keeping in well-closed receptacles. The coffee looks as if coated with varnish and even if kept for a long time suffers no loss of aroma.

To Prevent Potatoes in Cellars and Pits from Rotting.—On the ground on which the tubers are to be piled a thin layer of unslaked, finely pulverized lime is spread, then a layer of potatoes six inches deep, then lime again, and so on. The tubers thus treated remain free from disease and where rotting has already commenced it is stopped.

Preservative Paint for Boiler Shells.—Make a coarsely pulverized mixture of 25 parts of rosin, 2.5 parts of graphite, and 2.5 parts of black. Dissolve about 2.5 parts of this gradually in about 20 parts of boiling gas tar, stirring vigorously, then add about one-half part of tallow. This solution while warm is diluted with petroleum to 50 per cent, and with this mixture the boiler is coated to the water level, applying it as warm as possible.

To Repair Rubber Articles with Mastic Cement.—Carefully scrape the broken or split surface, spread on mastic cement, 30 parts of sulphide of carbon, 4 parts gutta percha, 8 parts comminuted rubber, and 2 parts of fish glue. The mixture should be applied in layers in the break with a spatula, as smoothly as possible, and the edges held against the mastic cement introduced, by tying firmly with a string. After 36 to 48 hours the parts will be joined, the string may be removed, and the protruding mastic seam pared off.

To Color Brass Buttons.—Golden Yellow: *a.* Dip them quickly into a perfectly neutral solution of acetate of copper, rinse and dry them. *b.* Mixture of 1 part mosaic gold with 4 parts of bone ash, rubbing the compound on with a moistened linen pad. Greenish Gray: Repeated applications of a very dilute solution of chloride of copper. Violet: Heat the brightly polished buttons to 140 deg. F. and moisten by means of a pad of cotton-wool with solution of chloride of antimony.

Cement for Insulators.—(For 100 insulators take 2¼ pounds) *a.* Asphalt, 2 parts; mineral tar, 1 part. *b.* Pitch, 2 parts; brick dust, 1 part. *c.* Lead or burned plaster, 4 parts; iron filings, 1 part. *d.* Iron filings, 20 parts; sal ammoniac, 0.66 part; powdered sulphur, with water or vinegar, 0.66 part. *e.* Cement, 4 parts; brick dust, 4 parts; iron filings, 1 part; and water. *f.* Glue with water, 3 parts; allowed to stand for 6 hours; add hydrochloric acid, 0.5 part, white vitriol 0.75 part, and expose for 12 hours to a temperature of 140 deg. to 158 deg. F. Further purification can be obtained by settling. This will not gelatinize.

Insulating Sheets for Electric Conductors.—The insulating material consists of 768 parts of rubber, 166 parts sulphate of antimony, 58 parts of sulphur, which may also be omitted, 195 parts of lime (chalk), 130 parts of magnesite, 922 parts of carbonate of magnesia. The production of insulating sheets, tablets, or rolls from this mass, which may also be mixed with Chinese gum lac, the acidity of which is neutralized by boiling with carbonate of potash, consists in placing a suitable number of plates made from this substance between sheets of zinc, one on the other, and then vulcanizing them at a temperature of 250 deg. to 300 deg. F. and under a pressure of 132,000 to 220,000 pounds. The gum lac may be replaced by vegetable fibers. During vulcanization at an augmented temperature (of 300 deg. to 340 deg. F.) the rollers may be dusted with talcum powder or the like.

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operator. Millions of feet of insect and fire-killed timber in the West are standing untouched in the forest. Under present conditions this timber is not only useless, but is an actual detriment to the forest. Much of this dead wood possesses all the requirements of high-grade structural timber, with the single exception of durability. Often where dead timber is most abundant there is an almost complete absence of the naturally durable kinds of wood, and timber for structural purposes—ties, mine timbers, poles, posts, etc.—must be transported long distances at heavy expense. The thorough seasoning of several years has strengthened the dead wood and put it in an excellent condition for treatment. Fortunately, most of it is of a kind which readily absorbs the liquid preservatives, and so is well adapted to successful impregnation. Therefore, expensive pressure plants are, in most cases, unnecessary, and the cost of erecting and operating a small open-tank treating plant is surprisingly low. In the South the cheap and abundant loblolly pine, one of the easiest of all woods to treat, can by proper preparation be made to take the place of the high-grade long-leaf pine for many purposes. Black and tupelo gums and other little-used woods have a new and increasing importance because of the possibility of preserving them from decay at small cost. In the Northwestern and Lake States are tamarack, hemlock, beech, birch, and maple, and the red and black oaks, all of which by proper treatment may help to replace the fast-diminishing white oak and cedar. In the States of the Mississippi Valley the pressing fence-post problem may be greatly relieved by treating such species as cottonwood, willow, and elm.

SCIENCE NOTES.

Platinum, which sold at $40 an ounce a year ago, has taken a big decline, and is now quoted at just half as much, $20 an ounce. The price of platinum doubled between 1905 and 1907, and is now back to the 1905 price. It sold as low as $8 to $10 an ounce fifteen years ago.

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